

CONSIDERATIONS
ON THE
MEDICINAL USE,
AND ON THE
PRODUCTION
OF
FACTITIOUS AIRS.

PART I. By THOMAS BEDDOES, M. D.

PART II. By JAMES WATT, Engineer.

EDITION THE THIRD.

Corrected and Enlarged.

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CONTENTS.

	Page
Dedication.	
Advertisement to third Edition.	
Preface to second Edition.	
I. Of the Atmosphere - - -	9
II. Of the breathing of man and similar animals	11
III. Important question - - -	13
IV. The effect of breathing oxygene air little diluted - - -	ib.
V. How respired oxygene affects venous blood	16
VI. Experiments with an atmosphere of an higher standard - - -	19
VII. Connection of oxygene with muscular motion	23
VIII. Animal charged with oxygene - - -	26
IX. Airs in the cellular substance - - -	27
X. Experiments with mephitic airs - - -	29
XI. How respired hydrocarbonate affects venous blood - - -	37
XII. Reflections - - -	38
XIII. Hydrogene respired - - -	41
XIV. Supplemental facts respecting oxygene - - -	43
XV. Tables for mixtures of airs - - -	49
XVI. Production of factitious airs - - -	51
XVII. Cases in which oxygene air was administered	55
Dr. Thornton's letter—Mr. Atwood's journal	57
Mr. Corp's letter on Mr. Atwood's case - - -	59
Second part of Journal - - -	60
Letter from Mr. Atwood - - -	64
Cases of J. Patterson and Mrs. ——— - - -	65-66
Mr. Barr's letter - - -	68
Dr. Carmichael, on <i>gutta serena</i> - - -	70
Ditto, on chlorosis - - -	74

	Page
Letter from Dr. R. Pearson -	76
Ditto from Dr. Thornton -	78
XVIII. Administration of unrespirable airs -	83
Letter from Dr. Ferriar -	<i>ib.</i>
Ditto from Dr. Carmichael on consumption	15
Ditto from Dr. Ewart on ditto -	93
Ditto from Mr. Chisholm on ditto -	102
Ditto from Dr. Carmichael on Asthma -	105
XIX. Mr. Watt's hints -	107
XX. Of substances that may be supposed to act	
chemically -	119
Dr. Garnet's letter -	<i>ib.</i>
Mr. Sandford's -	126
Dr. Johnstone's -	143
Dr. Darwin's dusting-box -	150
Corrective of ill-tasted eructations -	<i>ib.</i>
Mr. Capper's apparatus for animals -	152
XXI. Miscellaneous facts and reflections -	153
Experiments with oxygene hydrocarbonate	154-5
Medical effects of oxygene -	163
Dr. Trotter's letter -	165
Mr. Gimbernat's treatment of hydrocele -	166
Of hydrocarbonate -	168
Tendency of unrespirable airs to produce	
sleep -	<i>ib.</i>
Mr. Darling's letter -	169
Dr. R. (not W. Pearson's letter -	171
Of some doubts and scruples -	177
Dr. Jenner on the nature of tubercles -	178
Part II. -	181

Addenda.—Dr. Jenner on tubercles---Ditto on the effects of bad air---Mr. Field on the advantage of inoculating with diluted matter---Mr. Bent on a case of cancer where fixed air was used externally.

TO MR. WATT.

DEAR SIR,

You will probably be startled when you read your name on the page destined to dedication ; but I cannot prevail upon myself to send these considerations a third time abroad, without acknowledging my satisfaction in having had you for a fellow labourer. To establish a new department in Medicine, would have exceeded my single strength ; and I do not know any person who could have afforded me such effectual assistance as you have done.

That the pneumatic practice is beginning to acquire the certainty of a genuine art, may be too bold a thing for me to assert ; but if this should prove to be the case, I need not explain how much it is indebted to you for the rapidity of its progress, the means of judging being fully before the public. The zeal, however, with which you exerted your talents to do good, could be witnessed but by a few ; and it is particularly incumbent on me to return thanks both to you and Mr. BOULTON, for so liberally consenting, at my earnest request, to manufacture your air-apparatus. The profits were never likely to requite any man—much less persons engaged in such extensive concerns—for the expence and vexation always occasioned by a new branch of business.

Though you have succeeded so far as to enable any one, who chooses, to procure elastic fluids with perfect ease, and in the utmost abundance, I hope you will not entirely abandon the subject. By turning your thoughts to it from time to time, you will not fail to help us forward by some useful hint, or happy invention.

Of those members of the medical profession, who have already made trial of factitious airs, the desire of certainty, or the uneasiness of doubt would ensure the perseverance, even though they had met with no direct encouragement. Others will feel it their duty or interest to adopt the same practice. Nor will the sick or their friends be universally quieted by unmeaning objections or over-awed by that authoritative tone which ignorance—and medical ignorance, more especially—is so apt to assume. Notwithstanding the times, a much more lively interest has been manifested by the public in this arduous undertaking than I could have expected. And should the pursuit, which I by no means apprehend, be abandoned here, it will be continued in other countries. I could prove by sufficient testimonies, how favourably the proposal for the extensive employment of aeriform remedies has been received in different parts of the civilized world. At present I shall only remark, that a celebrated American Physician is composing a work, to explain the most remarkable appearances of the yellow fever of PHILADELPHIA, according to the principles stated in the following pages. Should his explanation be true to nature, the same principles will doubtless suggest effectual means for checking the ravages of this consuming disorder in future.

No contingencies therefore, it should seem, can altogether put a premature end to these interesting researches. When the time for balancing success and failure shall arrive, the result, I trust, will not diminish the satisfaction you must have derived from cases within your certain knowledge.

I am, dear Sir,

Your's with sincere esteem,

THOMAS BEDDOES.

Clifton, Feb. 10, 1796.

ADVERTISEMENT.

THE additions to this third edition, which appears so soon after the second, though not very numerous, are of some importance. That the purchasers of the second edition may have no cause of complaint, their substance shall be given in part IV. which however, will not very speedily appear. These additions consist chiefly of letters from Dr. JENNER, Dr. R. PEARSON, Mr. ATWOOD, BENT, FIELD, and SANDFORD. The Author is glad to have it in his power to announce Mr. WATT's intention of publishing some new Observations on the application of chemistry and mechanics to the relief of the sick.

Since the distribution of the second impression of the Author's *Proposal for a Pneumatic Institution*, queries have been put to him which he scarce knows how to answer, because he finds it difficult to express his thoughts more distinctly than he has already done.

Had the respiration of elastic fluids, in so many trials, never produced the desired effect, there could have been no inducement to attempt improvements in the method of administering them: had they not frequently operated as mere palliatives in the simple way in which they have been administered, and frequently failed altogether, there would be no need of an Institution for the purpose of investigation.

In attempting the smallest good, circumstances will inevitably occur to provoke disgust. When any scheme, that requires contributions is talked of, persons pre-determined not to part with their gold, will often give futile reasons, instead of a frank refusal. By refuting these reasons ten times over, you will only tease yourself. The little secret motive, "the bosom's lord," sits all the while unassailable by rhetoric or reasoning. In such hopeless cases, I presume to offer a short piece of advice to the promoters of the design. *Maturus desine*—quit parley forthwith, and spare your unavailing pains.

T. B.

Clifton, Feb. 10, 1796.

PREFACE

TO THE SECOND EDITION.

THE former edition of this pamphlet, consisting of between 500 and 600 copies, appeared in the middle of October, 1794. The booksellers had disposed of most of the copies in a few weeks; and in less than four months a new impression became necessary. As the British market for professional publications is most discouragingly narrow, may not this brisk demand be regarded as the token of a rising disposition in mankind to take what belongs to their welfare into their own consideration; and to emancipate themselves still further from the danger and servility of implicit confidence?—Presuming that the present edition will likewise fall into the hands of persons, indifferent about medical literature in general, but anxious to form an opinion concerning the virtues of elastic fluids; I shall endeavour to obviate the effect of certain cavils, which will perhaps be urged with greater vehemence, as the projected improvement seems more likely to answer. In the past and present state of medicine there are several circumstances which may, in my opinion, be successfully employed for this purpose.

A

I. Let

I. Let the means by which alone it is possible for human ingenuity to improve this or any other art be first considered; and afterwards the difficulties it has been necessary to surmount before the most powerful articles of the *Materia Medica* could be brought into train. To discover an efficacious method of administering quicksilver, without inflicting the most severe torture upon the patient, required the successive efforts of many generations. Opium has been longer known and much more frequently exhibited; yet the number of those, who understand its properties so as to employ it safely and with its full effect, is at this day incredibly small. Nor would a stranger to the records of medicine ever conceive by what sufferings, and, to palliate nothing, by what sacrifices our present knowledge of these two substances has been obtained. This is a melancholy retrospect; but before you give way to sympathy, pause to consider what the alternative would have been. We possess the most authentic documents; and from them we may collect that the number of miserable lives and miserable deaths would have been many million times greater, if our predecessors had not persevered in their endeavours to master these active bodies. Such is universally the condition of human affairs; and the miseries of the present age will work out the redemption of posterity.

If

If you pursue this train of thought, you will, after some hesitation perhaps, be led to a conclusion opposite to that of the acute author of the work, entitled *Medicine pernicious to Society* (a); but if you limit the question to the past and the present, and comprehend practitioners of all titles and of both sexes, I dare not deny that for one pang that has been eased, an hundred have been inflicted: for one life that has been preserved, twenty have been destroyed.

It would not therefore have been a sufficient reason for abandoning elastic fluids in dispair, if in cases where there was no chance of other help, some suspicious circumstances had arisen after their use.—They have however now been very frequently and largely administered; and sometimes in a state of debility but just compatible with life. My attention and enquiries have been particularly directed to bad consequences. Yet I know only of three instances, where any inconvenience, more worthy consideration than the ordinary effect of an emetic, has been experienced. In the worst of these I had the mortification to be concerned; it is the case of epileptic affection related in my *Collection of Letters*. The patient is now as before the inspiration of the modified air; nor
has

(a) La Medecine nuisible à la Société by Dr. Gilibert, a Medical Professor of Montpellier.

has any thing worth mentioning occurred in the mean time.——Of the other cases Dr. Carmichael gives an accurate report p. 69-72: There is not, I believe, the least reason to suspect that life has been even once shortened in these attempts to relieve hopeless distress. Had such an event fallen under my notice, I should have described it as circumstantially as the most brilliant cure. Of the observations I should myself make, it was my original determination to relate such as might inspire caution rather than such as might suggest to high expectations; and I suppose common sense will dictate to every person in the same circumstances the policy of watching and reporting effects in the character of an adversary rather than of an advocate.

To imagine possibilities is one thing; to judge of realities is another. The imagination, I presume, may very allowably range the unexplored recesses of Nature in quest of remedies for frequent and fatal disorders. If any thing that appears capable of supplying so great a desideratum should occur, you must of necessity, in applying to its use, be guided by views or expectations, previous to direct experience. To frame analogical hypotheses concerning the operation of untried agents (unless the hypotheses be absurd, that is, contrary to well-established

lished

lished facts) can, therefore, bring no man's judgment into question, except with those who feel it their interest to confound, or who want capacity to distinguish, things essentially different. In the daily declamations against proceeding upon analogy in the practice of physic, there is so little meaning that the declaimers are continually endeavouring to avail themselves of this resource; they are only unconscious of what passes in their own minds. But to adhere to speculation in opposition to the evidence of experiment, is, I acknowledge, a degree of weakness, equal to the criminality of prevarication or direct falsehood, for the sake of gaining a lucrative reputation. My coadjutors appear to have been actuated by the same sentiments: and the impartial and intelligent may, I think, be safely challenged to determine how far their reasonings are distinguished by philosophical scepticism, and their reports by the austerity of truth.

In our clinical observations we must all be sensible that there is a degree of immaturity, which time only could remove. But it seems too obvious to require proof that the progress of the art and the advantage of patients are best consulted by speedy publication, provided the statement of facts be accurate as far as it goes. This is certainly the quickest way of multiplying

ing observers; and thus I expect the machinations of empirics and monopolists will be defeated.

II. No one will pretend that factitious airs are inert; and since they have been so freely used with so little injury, may we not safely persevere, till their virtues be ascertained? Is it too soon to conclude that the caution, at all times necessary in the practice of medicine, is sufficient for the security of the sick? and that any unfortunate event in future ought to be imputed to rashness, to ignorance, or to one of those mistakes in consequence of which the noblest remedies have sometimes proved pernicious? It is beyond expectation fortunate that the time of natural death should have in no instance coincided with the first administration of elastic fluids. For I saw Craft and Timidity, which formed a league to expel Peruvian bark from the shops, to oppose inoculation, and to decry the cool treatment of the small-pox, ready to take advantage of any event that might bear an alarming interpretation.— That so little opposition and so little pretext for opposition has arisen, I impute to a variety of causes; to skill and care in individuals; to our superior knowledge of the nature of animation; to instructive experiments upon animals; and, above all, to that power over invisible and impalpable agents which we derive from mechanics and chemistry.

III.

III. By several who viewed this project with an evil eye, it was doubtless expected that it would be defeated by its own difficulty. But it has escaped this danger, and others, according to the course of medical transactions, await it. That which will arise from the following cause I regard as most to be dreaded. Unless the enemies to improvement sacrifice their fees to their stubbornness, they will be compelled by the urgency of patients to employ the new method or to *make believe* they do. In what disposition of mind they will set about the trial may be conceived by those who recollect the occasion on which the Jew in Shakspeare demands

“ On what compulsion must I, tell me that ? ”

Modern instances might easily be adduced where an active and well-recommended material has been presented to the public, as unfit to be prescribed, on the authority of cases in which it had been converted by the enormity of the dose into a poison. When factitious airs fall into the same hands, we shall, I dare say, be furnished with instances in plenty of their injurious effects; for I repeat what I have already taken some pains to inculcate, that like all efficacious remedies they are capable, when misapplied, of producing the most fatal consequences.

IV. Knowledge is never exact but when it involves absolute or comparative quantity.
To

To perceive clearly in what estimation the general art of healing in its present condition deserves to be held, we should know,

1. The number of cases where it can effect a cure, though no spontaneous recovery would take place.

2. The number of cases where we are helpless spectators.

3. The pain we can save patients whether spontaneous recovery will or will not take place.

Were these quantities ascertained, the figures on the melancholy side of the account would, I fear, run tremendously high. But let us suppose that in a given district there are 10,000 patients, where the drugs in use can neither preserve life, nor in any considerable degree mitigate pain. Of these 10,000 cases let it be assumed that in 1000 or in half the number factitious airs are capable of re-establishing health, and in 2000 others that they will prove better palliatives than we possessed before. That their efficacy will hold so high a proportion I by no means affirm; though facts seem to warrant very favourable expectations, and the signal virtues they have manifested in internal and external ulcerations, that is to say, in curing or relieving the most fatal and excruciating

ating of human maladies, is a most encouraging consideration. But though their advantages should require to be expressed in much lower terms, it is obvious that they may still be an acquisition to humanity; and I have offered a numerical statement merely to evince their value, if they should prove serviceable in any species of disease, though they fail in all others. The habit of analysing medical facts is so uncommon that the diffident and the uninformed might by a little management be led to infer general want of power from partial inefficacy. It was accordingly remarked to me by a physician, acquainted with the history of his art, the feelings of his brethren, and the spirit of the metropolis, “that some patients might possibly
 “be cured by breathing this or that air; as
 “others are by swallowing this or that drug.
 “But the method, unless mysteriously practised,
 “cannot soon obtain credit; persons out of
 “the profession are too indolent or ignorant to
 “concern themselves about its pretensions: it
 “appears troublesome and would put the fa-
 “culty too much out of their way; I think
 “therefore success in twenty instances will not,
 “at present, be so likely to recommend it, as
 “one failure to bring it into discredit.”——I acknowledge the shrewdness of these remarks; and I am sensible that it is a thing of itself by no means desirable to *put the faculty out of their way.*

way. But superior considerations will easily occur; and it remains to be seen whether the public judgment, almost 200 years after the time of BACON, is so enfeebled by medical superstition, as to yield in a matter of such moment to vague presumptions and opinions of questionable origin.

To the former edition I prefixed a proposal for a MEDICAL PNEUMATIC INSTITUTION. A *temporary* public establishment might, I conceived, be so contrived as greatly to assist in deciding how far elastic fluids will be of service in diseases, which are a reproach to the art and mines of gold to its professors.----Among the peculiar advantages of such an institution persons of information appear to have been most struck with the following. 1. To a complete trial of this practice it might be necessary to fill apartments with modified air: Even unfavourable conclusions should be established in such a manner as to leave no regret behind; and persons of enlarged views will, I suppose, assent to an observation of Mr. Thomas Wedgwood, "that it is worth while to expend "the specified sum in order to assure ourselves "that elastic fluids will not be serviceable as "medicines." 2. It would be desirable to have the means of applying this practice to animals --as dogs and horses--labouring under dangerous or fatal disorders. 3. We might carry on
physiological

physiological investigations of longer duration and greater extent than have ever yet been devised, with a view to discoveries, applicable to the practice of physic. 4. As all imaginable precautions would be taken to authenticate facts and give them publicity, a large quantity of matter for reflection, if not of knowledge immediately useful, would be thrown into circulation. 5. Observations on private patients may suggest modes of applying air, not easily practicable but in an appropriated building. 6. It may be expected that men of genius, having such assurance that all reasonable suggestions would be realised, would universally exert their inventive powers in behalf of humanity.

According to the common acceptation of the term *charity*, the proposed institution must be regarded as essentially different from ordinary charitable foundations. It is calculated for the benefit of the wealthy as well as of the indigent; in other words, to relieve the distress universally arising from the imperfect state of medicine, and not from poverty in particular. It can scarce be suspected as a private or party job; there are few individuals incapable of judging how far the undertaking is unnecessary; for there are few who have not seen some friend tortured long or prematurely cut off by a disorder, which has baffled the skill of those in
whom

whom most confidence was placed, and from which they themselves are furnished with no exemption.

The proposal having been some months before the public, it may be expected that I should say something of its reception. It has incurred ridicule; that was in order. It has also been commended; indeed, if I may credit the reports of some correspondents, and if *words* could procure workmen and materials, the present age might have consecrated to humanity an edifice more splendid than the monuments of oriental superstition. These commendations however might be mere civilities; but I can seriously affirm that no design has ever been sanctioned by more respectable support. The sum at present subscribed does not, I believe, exceed * six hundred pounds. But among the subscribers will be found a majority of the persons, eminent in Great Britain and Ireland as improvers of medical and philosophical science. Their names shall speedily be given to the public. But I think it due to departed worth to record on the present occasion that the promotion of this design was among the last acts of the ingenious and public-spirited Mr. Wedgwood. In my former advertisement I thought myself bound in justice to mention the liberality

* It is now more than Eight hundred.

lity of Mr. William Reynolds, of Mr. Joseph Reynolds, and Mr. Yong, surgeon, of Shifnal, Shropshire. In 1792, when I pointed out the principles on which I imagined beneficial consequences might result from the free use of elastic fluids as medicines, these persons agreed with me to risque a sum not exceeding two hundred pounds each, in order to bring my conjectures to a proper trial. An apparatus was accordingly erected; an operator engaged, and in 1793 I made many of the following experiments. At the same time it was ascertained that the practice might very safely be pursued: and a prospect of advantage offered itself. Upon this first essay was expended no inconsiderable part of the sum we had determined not to exceed.

I have observed of late certain expressions in print, from which strangers to the real circumstances might suppose that several other persons had co-operated with me in attempting to improve Medicine, in consequence of previous connexions in private life. But there has been in this proceeding nothing of narrow partiality towards an individual, nothing of collusion or cabal. The real motives of those who have stepped forward are so much more honourable to themselves, and to the cause in which they engaged, that such misapprehension ought to be

be obviated. In truth, I have not even a personal acquaintance with the majority of those by whom I have been favoured with communications; nor had I the least previous intimacy or correspondence with any one among the number, excepting a physician eminent for the variety and energy of his talents; and our acquaintance was confined to an intercourse of letters on subjects of medicine and philosophy.

Advertising the proposal and contribution in the London papers has been delayed longer than was intended. But the necessities of the poor during the late disastrous season were so urgent that it was thought the public would not pay much attention to other applications for subscriptions. As soon as the contributions amount to fifteen hundred pounds, I shall propose to the subscribers to proceed to the execution of the design, in hopes that the sum further necessary, will afterwards be raised.-- I have sometimes been asked if it would not be better to defer the project till peace be restored? I think indeed that less difficulty would have been experienced in time of peace; but I have thought it not improper to reply by another question: *If you admit the propriety of the measure at any time, should a nation like this defer a plan, requiring for its execution no more than 3 or 4000l. and calculated to rescue multitudes from suffering and death? Can you suspend*
the

the progress of disease, till you are at leisure from the pressing concerns of the war to contribute your mite towards the alleviation of distress, which is gnawing the bosom of innumerable families? Besides, where is our security, that at the cessation of hostilities, or shortly afterwards, we shall be better able or more willing than at present to execute schemes of beneficence? And would it not be a cause of just regret if we should suffer to pass away so noble an opportunity of deserving well of mankind, at such a trifling cost?

The following Bankers in London have obligingly agreed to receive Subscriptions for the Medical Pneumatic Institution: Messrs. Coutts and Co. Sir J. Esdaile and Co. Messrs. Pybus and Co. Messrs. Ransom and Co. Mess. Smith, Payne, and Co. Mess. Staples and Co. ---Sir Benj. Hammett, Alexander Anderson, Esq. and John Grant, Esq. have consented to hold the money subscribed, as Trustees, till the execution of the design commences.



PART I.

EXPERIMENTS, CAUTIONS, *and* CASES

tending to illustrate the medicinal use of
FACTITIOUS AIRS, and of other substances,
of which the application to Medicine has been
suggested by modern philosophical discoveries.

I. — *Of the Atmosphere.*

IT is proved, by satisfactory experiments, that the inferior region of the atmosphere consists of two kinds of air, quite distinct in many properties. One is the kind called VITAL, DEPHLOGISTICATED, or OXYGENE AIR, and by a variety of names besides. The other has been named AZOTIC, PHLOGISTICATED, FOUL, or BAD AIR. Where the lower atmosphere is not altered by the breathing of animals, the burning of fuel, by exhalations from subterraneous chemical processes of putrefying substances, and such local causes, if you confine and examine an hundred cubic inches, you will find twenty-seven or twenty-eight to be oxygene and the remaining seventy-two or seventy-three azotic air.

air. The manner in which air may be analysed, is described in the writings of Dr. Priestley, Mr. Scheele, Mr. Cavendish, and Mr. Lavoisier. These authors explain much of the nature of oxygene and azotic air. A candle burns in a vessel full of oxygene air with dazzling brilliancy, and is consumed with great rapidity. This air unites with various substances, and turns them sour, as beer and milk. Blood taken from a vein is of a dark or livid colour; oxygene makes it bright, florid or ruddy. You may see this difference by breaking a clot of blood that has stood a little time in the air; the surface will be crimson, the inside dark, and the dark part, now become the surface, will turn ruddy, though covered with serum. When black blood is put into azotic air, it does not become ruddy. Azotic air extinguishes flame, does not burn when mixed or in contact with common air, and is not absorbed by lime-water.

Near the earth these two airs are found mixed with surprizing exactness. Take a cubic foot from ten different places, and you will find that a little more than a quarter of each is oxygene, and the rest azotic air. There is often likewise found a little carbonic acid air, as one part in an hundred, though no fires burn, or animals breathe near. —The nice balance of attraction between the two constituent parts of the atmosphere, deserves notice. These two substances, when closely united, form nitrous acid: If, therefore, they were not, by some circumstances, prevented from uniting closely, all the oxygene, with part of the azote, would be changed into an highly corrosive acid, and the
waters

waters of our globe would be converted to *aqua fortis*. Again, azotic is lighter than oxygene air ; if, therefore, they had not some attraction, they might separate, and any animals, that should be immersed in an atmosphere of azotic air, would almost instantly expire : The undiluted oxygene remaining below, would, as we shall presently see, occasion violent diseases in man, as well in many other animals.

II.— *Of the breathing of man and similar animals.*

Fix a pipe to a bladder full of air, and, holding your nostrils, breathe the air for some time, and your distressed feelings will inform you that it is no longer fit for breathing. If you transfer this breathed air into an inverted glass jar full of water, and turn up the jar so as to keep in the air, and admit none from the atmosphere, you will find that it extinguishes a candle, and destroys the life of a small animal, dipped into it. If you procure another quantity of such air, and add to it a little more than one fourth of oxygene air, a candle will burn in it just as in the atmosphere ; and you may breathe it as long as so much fresh air, though it is not exactly the same ; for it contains, after being breathed, some fixed or carabonic acid air, either thrown out from the blood, or formed in the lungs. These experiments indicate, that breathing renders common air unfit for supporting life or flame, by depriving it of oxygene. Various other experiments shew further that this is the case. The blood, before it passes through the lungs, is dark ; after passing, it is florid ; dark blood in a bladder, exposed to the atmosphere, becomes florid superficially ; and in breathing, the blood

and air are only separated by membranes not unlike a bladder. When dark blood is introduced into vessels containing oxygene or common air, the blood becomes ruddy, and the air is reduced in quantity. Hence it appears, that the blood constantly drinks up a portion of the oxygene air, received into the lungs; and from various considerations I conclude that it is consumed in the contraction of the muscles, and in the formation of several fluids, secreted from the blood: for the blood, after traversing the body, comes back to the lungs dark, or without the oxygene, which it received in passing through them. In saying that this principle is *consumed*, I mean no more than that it enters into new combinations; quitting the blood and muscular fibres, and forming perhaps an ingredient in those salts which the bones and fluids are found to contain.—It has been calculated, that, an healthy man requires about five cubic feet of air, or $1\frac{1}{2}$ cubic feet nearly of oxygene air, every hour.

So much is premised to render the following experiments and speculations intelligible to some readers.—They will find more in Dr. Goodwin's *connection of life with respiration*, Mr. Coleman's *dissertation on suspended respiration*, Dr. Menzies' *Tentamen de respiratione* (*Annales de Chimie*, 1791, p. 211) in my three publications on the propriety of employing elastic fluids in various disorders, and the chemical authors already quoted.

It appears that the skin imbibes and exhales air. It will imbibe various kinds; but, as it is found in equal times to take in three or four times as much oxygene
air

air as any other, it probably selects oxygene alone from the atmosphere. Some philosophers suppose the human species to have existed in a monkey state; would the air then so much prevent the cutaneous absorption of oxygene as the cloaths at present? — From these experiments it may also be conjectured that immersion of the naked body or limbs in different airs might cure diseases.

III.—*Though the proportion of oxygene in the atmosphere may be best adapted to the average state of health, may the proportion not be smaller than is beneficial in some disorders, and larger than in others?*

Considerate persons will, I conceive, reply, that this is probable. I have made many experiments on animals, to illustrate the effect of atmospheres of various constitutions. I should have made more, had I not been absent from England, or otherwise occupied for a good part of the last 12 months. No investigation of greater importance or extent, can be imagined. This is only a rude beginning. Others will assist in continuing the enquiry,

IV.—*The effect of breathing oxygene air little diluted.*

Dr. Priestley and Mr. Lavoisier found animals either to die, or to become exceedingly ill in such air, while it continues more oxygenated than the atmosphere, and will support the life of other animals. It is not then defect, but excess of oxygene, that is pernicious here. The heart and arteries pulsate more quickly and forcibly; the eyes grow red and seem to pro-

trude ; the heat of the body is said considerably to increase (a), sweat to break out over the whole body, and fatal mortification of the lungs to come on. These appearances denote violent inflammation : animals have always appeared to me to suffer extremely, soon after immersion in unmixed oxygene air. The human species, I think, will be found to vary as widely in the manner in which this elastic fluid affects various individuals as in any quality whatsoever. Some, I have observed, not to be very sensibly affected by it when respired pure. To my own lungs, it feels like ardent spirits applied to the palate ; and I have often thought I could not survive the inspiration of oxygene air, as it is driven from manganese by heat, many minutes. The production of inflammation is fully established by dissection, as others have found, and as appeared from the following experiment : — A large kitten was kept seventeen hours in a vessel containing several cubic feet of air from manganese, of which about eighty parts in a hundred might be oxygene. This, and another kitten of nearly the same size, which had lived as usual, were then dissected, in my presence, by Mr. Guillemard, of St. John's College, Oxford, who immediately made the following minute of the appearances : — “ The lungs were of a florid red color in the “ oxygenated kitten (A) ; in the other (B), they were “ pale ; the difference was very striking, both in the “ inflated and uninflated state ; the edge of one lobe “ in A was marked with livid spots (as in mortification). The pleura was likewise evidently inflamed. “ The heart in A was of a florid red colour. The “ liver,

(a) Girtanner Antiphlogistische Chemie, p. 263.

" liver, kidneys, spleen, and blood-vessels of the me-
 " sentery and urinary bladder, were of a brightish red
 " colour. In B, the heart was of a deepish colour.
 " The liver, spleen, kidneys, and blood-vessels, in ge-
 " neral, were of a bluish or purple colour. Both kit-
 " tens had been successively killed by immersion under
 " water. Upon opening the head of A, there was no
 " appearance of inflammation.—The blood vessels had
 " rather a florid colour; but there was no sign of ex-
 " travasation, or more than the usual quantity of blood.
 " In B, on raising the skull, there appeared a quantity
 " of blood between the bones and the membranes of
 " the brain, of which the blood-vessels were turgid
 " with dark-coloured blood.

" In A, the heart readily obeyed the stimulus of prick-
 " ing: The spontaneous contractions of the right au-
 " ricle and ventricle were frequent; they continued
 " with little diminution of frequency and force for
 " above half an hour. In about an hour, they had
 " wholly ceased.

" In B, the irritability of the heart was at first equi-
 " vocal. On opening the pericardium half an hour
 " after the sternum had been removed, the motions of
 " the heart became very visible; they continued more
 " than an hour after the first exposure of the contents
 " of the thorax."

The universally diffused florid colour in A was par-
 ticularly striking; so was the dulness of one heart at
 first, and the vivacity of the other. Of the latter, I
 believe the spontaneous pulsations were in all many
 times

times more frequent and forcible ; though this circumstance deserves more particular examination than we bestowed upon it. The kitten A had eaten some time after being put into the reservoir, as appeared from food introduced at the same time. The air seemed to have suffered little diminution either in quantity or quality : the reason will appear from a subsequent experiment. On cutting the wind-pipe of A, to blow up the lungs, a good deal of viscid mucus flowed out. This was occasioned by strong action continued for some time, and was not seen in any thing like the same degree in B.

V. — *Experiments to ascertain the condition of the venous blood in animals made to respire oxygene air.*

Upon comparing the experiments made upon blood out of the body, I was formerly uncertain what might be expected to be the effect of hyper-oxygenation of the system upon the colour and other qualities of the venous blood. (See my observations on consumption.) Many substances, containing oxygene, brighten venous blood, but oxygenated marine acid, according to several foreign chemists of reputation, has an opposite effect. Mr. Guillemarde and myself often noticed the dark appearance of the veins in animals charged with oxygene, and of the blood they discharged when wounded. To investigate this point more particularly, one of two equal half-grown rabbits was kept fifteen minutes in a mixture of three parts of oxygene air from heated manganese, and one part of atmospheric air. Both were killed by blows on the back of the head, and opened nearly at the same time. This experiment

periment was made in the presence of Mr. William Clayfield, and Mr. Bowles, Surgeon, of Bristol. In the oxygenated rabbit neither the *vena cava* itself, nor blood taken from it, appeared less dark-coloured; we thought (but were not certain) that it was rather more so. The blood of the oxygenated rabbit coagulated much more rapidly. The liver also was of a much less dark colour in this rabbit.

The blood of both gained its usual florid colour on standing exposed to the air.

EXPERIMENT 2. — Of two equal and nearly full-grown rabbits, one was kept a quarter of an hour in undiluted oxygene air, prepared as before. Both were then killed and opened, as before, by Mr. Bowles. In the oxygenated the following were the appearances. The veins were certainly not of a lighter colour, nor the blood. A quantity from the *vena cava* of both rabbits was received in tea-cups. When it was spread thin on the sides of the vessel, we thought the oxygenated blood had a purple or claret colour, which was not perceptible in the other: Mr. Bowles likewise thought its general appearance rather darker. Its coagulation, as in the former experiment, was more speedy; and the coagulum, as I thought on examination afterwards, was firmer. — The liver was less dark.

On the margin of the lungs in the oxygenated rabbit, we observed florid spots in shape and situation like those I had formerly seen on the lungs of animals long confined in oxygene air; and which I take to be points of inflammation.

We observed signs of much stronger irritability in the right auricle and ventricle, in the diaphragm and the

the intercostal muscles of the oxygenated rabbit. They continued longer too in this. But considering the force and frequency of the contractions, the quantity of action would have been greater in the oxygenated, had the irritability continued five times as long in the other.

These phænomena made me wish for an opportunity of oxygenating animals of large size, as horses, and of drawing blood from their veins and arteries both before and afterwards. Such a train of experiments would form a very interesting supplement to Mr. Hunter's researches concerning the *general principles of the blood*. (See his *Treatise on the blood, inflammation, and gun-shot wounds*, p. 11—100.) The speedier coagulation of the oxygenated venous blood I think remarkable, and, as it happened in three experiments, it probably was not accidental. The more vigorous action of the oxygenated muscles too deserves to be compared by a course of experiments with the tendency of oxygenated blood to coagulate sooner. Several persons, of whom all did not know the one rabbit from the other, found the boiled flesh of the oxygenated, in both cases, more stringy, harder, and less juicy. The difference was most sensible in the young pair. The greater stringiness was apparent on both these occasions to the eye.

We observed that the rabbits drank repeatedly during their confinement in oxygene air. The latter had been watered a short time before ; I could not learn whether the former had or not. Perhaps this thirst (if such it was) depends on the excitement produced.

The

The conclusion directly deducible from these experiments, is, that the blood parts with that excess of oxygene upon which its florid colour depends, before it gets into the large veins, or indeed into any of the visible veins. The altered colour of the solids shews where the oxygene remains. But as we can never get to the end of our physiological enquiries, a further problem may be proposed : — “ If the oxygenation be continued very long, will not the solids be so highly charged as to be able to take no more oxygene from the arterial blood ? and will it not pass florid into the veins ? ” — If this does not happen, there must be some contrivance in the system to throw this principle perpetually from the solids. These who do not think that oxygene combines with the blood during respiration, have only to change the terms of my conclusion. The fact remains.

VI.—*Experiments with air, containing somewhat more oxygene than the atmosphere.*

In my letter to Dr. Darwin, I conjectured “ that if before immersion divers were to breathe air of an higher than the ordinary standard, they would be able to continue longer under water,” (p. 13). I made several experiments to determine whether this supposition was just ; in each two animals of the same litter were employed ; and as several spectators were sometimes present, they were desired to fix upon the weakest for oxygenation. The following report I literally transcribe from my journal, as it was settled and subscribed by the spectators : “ August 20th, 1793. Kitten C was placed in a mixture of nearly two-thirds oxygene air from manganese, and one-third atmospheric

" atmospheric air ; it was kept twenty minutes in the
 " vessel, which was from time to time supplied with
 " oxygene air, so as to keep the air better than atmo-
 " spheric air ; which was known by dipping a candle
 " into it, and observing that it burned with a brighter
 " flame. At the expiration of the twenty minutes, C
 " and D, which latter had breathed atmospheric air,
 " were immerfed in water till perfect asphyxia came
 " on. At the instant they were taken out, there ap-
 " peared in both a motion of the lower jaw ; C began
 " sensibly to recover, while D lay as dead. In a mi-
 " nute and a half, C rose, and began to walk about the
 " room, staggering at first, D being still motionless, or
 " nearly so : in this state it continued for fifteen mi-
 " nutes, when, for the first time, it raised itself, and
 " immediately afterwards fell on its side.

" CHRISTOPHER MACHELL.

" RICHARD LOVELL EDGEWORTH.

" J. GUILLEMARD.

" JAMES SADLER.

" THOMAS BEDDOES.

" Kitten D died the next day."

Of many similar experiments, it is sufficient to ob-
 serve, that the result was always in some degree the
 same ; sometimes the unoxxygenated animal failed to
 recover ; it was generally noticed that the oxygenated
 shewed signs of life under water the longest ; and some-
 times that it struggled as much as ever after its unoxy-
 genated fellow had ceased to move. Thus, in an ex-
 periment (September 28) a whelp, which had respired
 atmospheric mixed with one-third of oxygene air for
 thirty-four minutes, is registered to have been as much
 alive as before immersion under water, another puppy
 of

of the same letter unprepared, and immersed at the same time, having become motionless. These facts illustrate the query concerning divers. To obviate any mistake from difference of constitution, the experiment was sometimes repeated upon the same pair of animals, one being oxygenated one day, and the other the next, or the day following. The water in which they were drowned, was sometimes heated to the temperature of the body.

But as unequal quantities of liquid have been found to get down the wind-pipe of drowning animals, it seemed proper to repeat the experiment in another manner.—Accordingly, of two greyhound puppies of the same litter, ten days old, E the weaker was kept an hour and fifty minutes in a mixture of two-thirds of atmospheric air, and one-third of oxygene air from heated manganese. F was left as usual : Both were then immersed in hydrogen air. F soon appeared much agitated, and expressed much uneasiness. E moved very little, and soon placed itself in the couchant posture, with the head between the fore-legs and the muzzle resting on the bottom of the vessel. In five minutes, F was lying on its side, now and then breathing, which it did less and less frequently and more feebly. In ten minutes, this effort was scarce perceptible : In two minutes more, it was not once repeated. For the last six out of the twelve minutes, E was so perfectly still, that we were disposed to believe it dead ; and a person present said, “ this experiment will turn out ill for oxygene.” During these last six minutes, E had not inspired at all ; and from the first, the respiration was very infrequent.

At

At the end of the twelve minutes, both puppies were taken out of the hydrogen air; E immediately cried and struggled, F being quite motionless. They were laid before a fire; E cried, moved, and soon walked as usual; F seeming quite dead. In sixteen minutes, a stream of oxygen air was blown into F's mouth, but no sign of life appeared. The animal was afterwards opened; upon irritating the pericardium with a pointed knife, so as to press upon the heart, no movement followed; the pericardium being removed, the heart began to contract spontaneously: a stream of oxygen air being directed upon the heart, its action became more strong and frequent; the number of strokes was about seventy in a minute. The colour of the heart (probably from the filling of its own blood vessels) changed from pale to red. The difference of colour in the tongues of these puppies was striking, after the experiment, even by candle light, that of E being much more ruddy. The following variation seems worth transcribing from the journal: Of two puppies of the same litter, the weaker G was kept in atmospheric air mixed with one-third oxygen, and H for an equal time in atmospheric air with one-third hydrogen. Both were plunged into tepid water. H became motionless, while G moved with force, cried on being taken out, and seemed little affected.

The effect of oxygen air was very striking in recovering H. It began to move, and inspire the moment it was put into a vessel containing this air.

It was sometimes observed, that the movements of very young puppies under water, did not entirely cease in less than fifteen minutes.

VII.—*Necessity*

VII.—*Necessity of oxygene air to muscular exertions.*

The blood in the veins is dark ; in the arteries it is bright. When the respiration is straitened, the arterial blood becomes darker ; when access of oxygene air is prevented, all the blood becomes dark. In drowned and strangled persons, the face, lips, the skin under the nails, and some other parts, are of a violet or dark blue colour. Here the blood can receive no oxygene. There are a number of cases on record where, from bad conformation of the heart and adjacent great blood vessels, part of the blood only traversed the lungs ; the rest passed into the arteries again in the dark disoxygenated state in which it returns from the veins. Such persons are always blue or livid. They are extremely feeble ; in walking, are sometimes obliged to stop every third step, nor can they make any exertion of the muscles without instant panting and weariness. They commonly die suddenly ; you will find an account of such individuals in *the Commentaries of the Institutions at Bologna*. Vol. 6, p. 64. *Philosoph. Transactions*, vol. 55, p. 72. *Medical Observations and Enquiries*, vol. 6, in my *Medical Observ.* p. 62. *Abernethy's Surgical Essays*, part 2—Persons ill of sea-scurvy, often drop down dead in making a sudden effort, and from surprize. There is reason to believe, that either living in confined air, or on salted food, occasions a deficiency of oxygene in the fluids and solids.

Hence, if a person were to keep quite still, a given quantity of air should serve him to breathe longer than if he exerted himself. Thus should any persons find themselves again in the situation of Mr. Holwell and
his

his fellow-sufferers in the Black-hole prison at Calcutta, their best chance of surviving would probably be to forbear vehement struggles. The fever of the survivors appears to have been occasioned by the great stimulating power of fresh air, and of the sensations their escape must have occasioned.

The following experiments render probable the expenditure of oxygene in muscular exertion. They do not, however, absolutely prove this position; nor did their immediate result appear to me so certain as of my other experiments. Of two half-grown kittens of the same litter, one was teased to make efforts for half an hour, and then put into an air-tight vessel, in which it lived 48 minutes; the other lived 56 m. in the same vessel; it would require more such cruel experiments to decide whether speedier death here arose from previous consumption of oxygene by strong muscular action, and the subsequent necessity of a supply. It should be observed, that the first animal was not respiring more deeply than the second, at the time they were inclosed.

The following fact is remarkable, and countenances, but does not rigorously prove, the hypothesis. A grown cat was inclosed in an air-tight glass vessel.—She immediately became furious to a degree beyond what I ever observed in any animal under experiment. The violent agitation continued for 20 minutes. In 5 minutes more—25 minutes in all—she appeared dead: she was left in the vessel two minutes longer, and proved to be quite dead. A lighted candle was immediately extinguished on being introduced into the vessel.

Into

Into the same vessel another cat of the same size and age nearly, to which a small glass of white wine had been given half an hour before, was introduced. This cat sat almost perfectly still during the whole experiment. It lived 47 minutes, or nearly twice as long as the other.

In order to vary the experiment, half a glass of sherry was given to a kitten nearly grown. It was immediately put into the same receiver; and set to struggle very violently. It soon appeared to respire with difficulty. In 15 minutes the respirations were 98 or 100 in a minute. It did not respire after the 34th minute, and in 2 minutes more was taken out insensible.

A fellow kitten, no way prepared, was placed in the same receiver, and remained *very tranquil* for above a quarter of an hour; its respiration was never so frequent as that of the former; and it raised its head and breathed at the end of 41 minutes.

We have then

	Minutes.	Minutes.	
An harassed kitted living	- 48	} Difference 8.	
Its fellow, not previously harassed,	56		
A grown cat not prepared, but furiously agitated,	- - - - - 25	} Difference 22.	
Another perfectly tranquil, having drunk wine,	- - - - - 47		
A large kitten immediately after wine, and violent,	- - - - - 34	} Difference 7.	
Its fellow tranquil without wine,	- 41		

In these six experiments the same vessel, that is, the same quantity of air, was used. It may be said, by a

person unused to accuracy of terms, "no wonder the most exhausted animals should perish soonest." By considering a moment, he will perceive, that it is desirable to know precisely in what this exhaustion consists. I formerly conjectured that oxygene is consumed faster by an animal under the first operation of wine or other such stimulants; and Dr. Withering afterwards adduced the experience of Mr. Spalding in confirmation of this conjecture. It is not so easy to make the experiment upon animals; the efforts of some under confinement being so much more violent than of others. The last experiment was made with a view to this question, but the two preceding incline me to refer speedier death in this instance to the violent struggles, rather than to the wine.

VIII. — *Another comparative experiment with an animal charged with oxygene.*

Of two half grown rabbits (K and L) of the same brood, colour, size, and apparent strength, K was put into a large reservoir containing atmospheric air with a little oxygene. After some hours it was taken out, and placed for an hour longer in a mixture of nearly equal parts of oxygene and atmospheric air. It did not seem to suffer in its respiration. K and L, which latter had remained at large in the same apartment, were then inclosed in a vessel, and placed in a freezing mixture. In 20 minutes some of the cold brine was poured upon the bottom of the vessel in which the rabbits were: in 30 minutes L seemed affected, in 45 was scarce alive, and in 55 was quite lifeless and frozen stiff. K seemed sufficiently lively, only its feet were frozen stiff. They were dipped in cold water, and the animal recovered perfectly. I observed many convulsions and much tremor of the limbs during recovery,

very. It was between 8 and 9 o'clock in the evening when the rabbits were taken out of the vessel. K, by 12, had recovered the use of its fore legs, and being left not far from a dying fire within the fender, was found in the morning running about the room, when it eat cabbage leaves freely. It was kept alive for a week, when the legs appeared diseased from too quick application of heat at first.

The experiment being repeated without admitting liquor into the receiver, the result was similar. Would opium and wine enable an animal to resist the freezing mixture, as oxygene does?

IX.—*Experiments with oxygene and other airs, largely distributed through the cellular substance.*

Dr. Maxwell, assisted by Dr. Goodwyn and some other friends of accuracy and genius, forced different airs under the skin of animals, whence every person in any degree acquainted with anatomy, knows they would insinuate themselves far and wide through the body, in consequence of the free communication between different portions of the cellular substance.—

I. 4½ pints of *atmosphpherical air* were forced under the skin of a bitch, weighing 20lb. the incision was closed by a suture: the animal appeared uneasy and indisposed for 36 hours; the puffing did not begin to subside before the 9th day; on the 20th, no air was left except a little about the lower part of the belly.—

II. 3 pints of air, in which a light had burned out, were forced under the skin of a dog weighing 13lbs. For some hours the animal appeared stupid. The emphysema or puffing seemed to decrease during the 3d

day; on the 16th convulsions came on and frequently returned; on the 20th the dog died much debilitated. In three other experiments nearly the same phenomena were observed. — III. 4 pints of oxygene air were infused in the same manner into another dog; slight uneasiness was observed for the first hour, and afterwards the animal appeared exceedingly lively (*maxima alacritas*). Next day the emphysema began to lessen; by the 10th all the air was absorbed. In another dog of 19lb. $3\frac{1}{2}$ pints of this air disappeared in 8 days; in a third of 21lb. 3 pints in 8 days; in a 4th of 20lb. 3 pints nearly in 7 days. The 2d and 3d were affected as the first dog; the 4th was in no way affected. — IV. Carbonic acid air was infused into several dogs and rabbits. A large quantity (as much as 2 pints in a dog of 17lb.) disappeared during the operation; the rest was gradually absorbed in 4—14 days. No inconvenience followed, except in one case where a pint of air infused into a rabbit 3 months old, occasioned uneasiness from distension; but even here the animal eat with a good appetite in half an hour. The instantaneous disappearance of so much air in these experiments, was probably owing to its combination with the moisture in the cellular substance. Inflammable air (from metallic solutions, I suppose) occasioned heaviness and shiverings in two dogs; 3 pints in one, $2\frac{1}{2}$ in the other. Some detumescence was observed on the 4th day in both; in 13 days the air was all gone in the 1st, and in the 2d in 9 days. — VI. $2\frac{1}{2}$ pints of nitrous air were infused into a dog of 28lb. It howled as if in exquisite pain: in 15 minutes it staggered as if drunk; then convulsions came on, and vomiting with involuntary excretions. In 30 minutes it lay enfeebled on the ground, making deep and laborious

rious inspirations, in 54 $\frac{1}{2}$ it died, the convulsions continuing to the last. The heart had all its cavities full, and was quite inirritable. The lungs were of a pale saffron colour, and shewed no vestige of red blood. Brain in a natural state. In another experiment 1 $\frac{1}{2}$ pint of nitrous air produced the same effects, and death in 45 minutes. In neither case were the external muscles inirritable. Rabbits died just as these dogs, and the smell of nitrous acid was perceived when the lungs were inflated and left to collapse. In this thesis (Edinburgh 1787) Dr. Maxwell relates other experiments, in which airs were thrown into the blood vessels. By one (p 22) he shews that elastic fluids do not prove fatal till they get into the cavities of the heart. But as these latter experiments suggest no conclusion concerning the medicinal power of elastic fluids, I need not consider them at present. Mr. Achard, of Berlin, was the first who published experiments with different airs injected into the cellular membrane. But Mr. Achard is a writer whom you can seldom quote with confidence.

X. — *Experiments with hydrogen and other mephitic airs.*

Dr. Priestley, (*Exp. on Air*, N. Ed. I. 229) says
 “ Inflammable air kills animals as suddenly as fixed
 “ air, and as far as can be perceived, in the same
 “ manner, throwing them into convulsions, and there-
 “ by occasioning present death.” Dr. Priestly does
 not say how he ascertained the former part of this as-
 sertion, and I apprehend, it will be found erroneous,
 if it regard pure hydrogen. Mr. Scheele could make
 20 inspirations without inconvenience : and I have
 seen several persons breathe still oftener from a tube

through which a current of this air set, their nostrils not being closed (*Letter to Dr. Darwin, p. 44.*) Hence I concluded that this bland air might with impunity be breathed unmixed, longer than any other mephitic air, except perhaps azotic. Dr. Macdonald of Belfast, whose abilities and skill in physiological researches must be well remembered by all who studied medicine at Edinburgh ten years ago, confirms me in this opinion "I have tried (he informs me in a letter dated August 13, 1794) "hydrogen air in five pulmonary cases, in "two of which it had a very sudden and a very favourable influence. In one of the others the "measles supervened upon phthisis, and seemed to "decrease the first disease. My patients sometimes "respired hydrogen air for a minute and half at a "time; the more frequently they repeated the experiment, the more easy did it become: but after 15 or "20 inspirations I always observed the face to grow "dark and livid. I am astonished at the length of "time which man can breathe, and animals live in, "hydrogen air."

Dr. Gilby of Birmingham noted the following appearances, and immediately afterwards drew out this minute.

"Hydrogene Air."

"A mouse immersed in hydrogene air—from water and heated malleable iron—continued 30 seconds "without shewing any mark of distress; respiration "then became laborious; one minute 33 seconds "from the time of immersion it inspired; but it "moved no more, and when taken out, proved to be "quite dead.

"Fixed,

"Fixed, or Carbonic acid Air."

"Another mouse, immersed in this air, was instantly affected; and in 15 seconds was completely dead."

A young wood pigeon, in hydrogen air, ceased to gape and move in 2 minutes 35 seconds. For 10 or 15 seconds it did not appear incommoded. Its fellow, in carbonic acid air, ceased to gape and move in 43 seconds. It shewed distress instantly on immersion.

Very young animals do not drown so soon as old.— Imagining, therefore, that young animals would afford a more sensible scale on which to measure the power of different mephitic airs to extinguish life, I made the following experiment. A puppy, four days old, was put into a vessel of hydrogen air from heated iron and water. It ceased to breathe and move twenty-two minutes afterwards. Another puppy, of the same litter, was put into carbonic acid gas: it ceased to breathe and move in one minute and a half. — Comparative experiments of this kind require repetition; two apparently similar animals may be tenacious of life in different degrees, from causes not yet discovered: moreover, if immediately before immersion, one should have inspired, and the other expired, this might occasion a wrong inference: nor should dependence be placed on a slight difference. By keeping animals, seemingly equal, in different unrespirable airs, till all appearances of life in one or the other had ceased; then taking the survivor out, suffering it to recover, and after some days drowning it again in that air in which its fellow had perished before, I hoped to determine this question certainly for the subjects of experiment, and by analogy for all animals of the same class.

Accord-

Accordingly, three rabbits of the same litter, seven weeks old, nearly half grown, and weighing one pound and a half each, were successively immersed in three different kinds of air. Dr. Gilby being present at this experiment also, noted the appearances at the moment they occurred.

EXPERIMENT I. — RABBIT X.

" In hydrogen from water and heated malleable iron.

Minutes, Seconds, after immersion.

" In	1	20	Moved about, in appearance little distressed.
	1	50	Began to breathe short.
	2	0	Visibly distressed.
	4	15	Much agitated.
	7	0	Taken out, breathing very short and thick.
" In less than	17	0	Completely recovered.
" In	40	0	(that is as soon as food was offered) began to eat.

EXPERIMENT II. — RABBIT P.

" In hydrocarbonate air from hot charcoal and water, twice passed through water.

Minutes, Seconds.

" In	0	25	Breathed short, distressed.
	0	35	Violently agitated, continued so 15 seconds; inspired at long intervals for some seconds: scarce alive,

" After

	Minutes.	Seconds.	
" After	1	30	No inspiration or movement seen.
" In	4	0	Taken out for dead—did not recover.



EXPERIMENT III. — RABBIT Q.

" In carbonic acid air, from heated chalk."

	Minutes,	Seconds,	after immersion.
"	0	20	Strongly convulsed.
	0	35	Gasped at intervals.
	0	49	Has continued gasping.
	1	0	Nearly dead.
	1	15	Quite dead.
	2	0	Taken out, perfectly inanimate, did not recover.



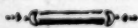
EXPERIMENT IV. — RABBIT R.

At the time of making these experiments I had not pure azotic air at command, and had neglected to use it when I had; the following observation makes it highly probable, that this air is not more suddenly deleterious than hydrogen. A candle having burned out in a vessel full of atmospheric air in contact with lime water, a very small kitten (about 14 days old) was put into the same portion of air; after the death of this kitten, which did not happen in less than 3 hours,

hours, the fellow of the three preceding rabbits was introduced: the following were the appearances.

Minutes.

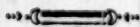
- | | |
|----|--|
| 1 | Breath short—turns rounds. |
| 3 | In no great distress, breath short. |
| 5 | The same. |
| 7 | Breath shorter. |
| 10 | Respiration apparently more laborious. |
| 12 | Taken out—very soon recovered—a candle plunged into the vessel was immediately extinguished. |



EXPERIMENT V. — RABBIT X. *again,*
at the interval of several days in hydrogen air.

Minutes. Seconds.

- | | | |
|---|----|--|
| — | — | At first very tranquil. |
| 2 | 5 | Snuffs for air round the side of the vessel. |
| 4 | 0 | Reclined almost on its side. |
| 5 | 30 | Breathes thick—very weak. |
| 6 | 10 | Taken out, breathing thick. |
| 7 | 10 | Could sit. |
| 8 | 0 | Could move, tho' still weak. |
| 9 | 30 | As usual. |



EXPERIMENT VI. RABBIT X. *a third time.*

At the interval of two days—recent hydrocarbonate, prepared without superfluous steam.

- | | | |
|---|---|-------------------------------------|
| — | — | Distressed the moment of immersion. |
|---|---|-------------------------------------|

<i>Min.</i>	<i>Sec.</i>	
○	20	Scratched the vessel furiously.
○	25	Fell on its side.
○	35	Motionless and insensible— taken out.
—	—	Lay as dead some time; finally recovered.

Another rabbit of the same brood, (before immersion in water, visible much affected with fear) struggled with strength for a minute and an half. At the end of two minutes, forty seconds, it moved; in three minutes was taken out, but did not recover.

Should these experiments be repeated by a person, careful to procure his elastic fluids free from offensive acid fumes, the distinctness of the phænomena I observed, persuades me that their general result will be confirmed. Of some readers, whom the importance of the subject may lead to take up this pamphlet, the curiosity will, I fear, be repressed by sensations, arising from the idea of pain endured by the animals. In a few cases, the torture which was inflicted was exceedingly repugnant to my own feelings; and for this reason, I have left one series of experiments (SECT. vii.) more incomplete than I could easily have rendered it. Against drowning, an imputation of cruelty will hardly lie: Animals, destined to this death, may just as well drown for the instruction of the physician. Besides, did not accustomed acts of outrage and injustice daily pass uncensured, I know not how he who feeds upon the flesh of a slaughtered animal can consistently condemn

demn investigations, seriously tending to restore or preserve health, though conducted at the expence of the life and ease of animals, unable to resist the power of man. I wish, with all my heart, I could prove that morose writer in the wrong, who has called the Earth **A VAST FIELD OF BATTLE**, where creature, for preservation, preys upon creature, or tortures its fellow in pursuit of pleasure.

Two kittens immersed, one in carbonic acid, the other in hydrogen air, afforded a similar result; that is, the carbonic acid appeared full three times as deleterious as hydrogen.

Finally, to render the difference again more distinct, two equal quantities of atmospheric, were successively mixed with an equal bulk of carbonic acid, and of hydrogen air. A rabbit (S) being put into the mixture of atmospheric and carbonic acid air; the following observations were made.

Minutes.

In	2	Appeared weak.
	4	Has been couchant for 2 minutes.
	6	Very still.
	11	Respiration more laborious.
	26	Extremely weak; seems ready to fall on one side; scarce alive.
	43	Quite dead.—After the 2d minute it never rose—death very lingering.

A fellow rabbit, T, in atmospheric and hydrogen air, seemed much less distressed at first; rubbed its fore-feet after it had continued in the vessel 40 minutes,

nutes, and performed several other actions; much of the time it sat, that is, it continued erect before. Even at the last, no distress, except quick respiration, was observable.

In 48 minutes it was taken out; it now stood firm; and though unwilling to move; was capable, when urged forward, of advancing, without staggering, or any sign of great debility. In appearance it had suffered less in 48 than its fellow in 15 minutes.

XI.—*How hydrocarbonate air affects venous blood.*

Two fowls were strangled and a rabbit was drowned while their fellows were immersed in hydrocarbonate air. In all these last the veins appeared of a brightish red colour! the liver and heart (which was perfectly irritable) were also of a bright colour. In the others the liver was dark as usual; and the heart pale. In the hydrocarbonated rabbit the flesh was universally of a light lively red. The blood from the *vena cava* had the same brightness; it coagulated about as soon as the livid blood of the strangled fowls and drowned rabbit. The boiled flesh of all the fowls had much the same taste and toughness. The muscles of the lower extremities of the hydrocarbonated fowls were of a lively red. The boiled flesh of the h. rabbit had a pink hue. Of two equal fowls one was put into hydrocarbonate and one into carbonic acid air; the former was ruddy throughout, as was well seen in the heart cut across. In the fowl put into c. acid air nothing of this bright red colour appeared. The liver I thought paler than in strangled fowls: but I had not one at hand for immediate comparison. Of this last h. fowl the wings and breast were brown, and the thighs reddish.

XII. *Reflections*

XII. *Reflections on the preceding facts.*

The attentive reader must have seen, even in the result of these simple extemporaneous experiments, indubitable proofs of the power on factitious airs variously to affect the living frame. It appears that oxygene air, when inspired pure, or nearly so, increases the motions so as to produce dangerous or mortal inflammation; that by reddening the blood, it brightens the colour of the solid parts; even that of the liver, which anatomy shews to be the least likely of all the solids to be affected by any change of the arterial blood; that it renders animals less capable of being drowned or destroyed by cold; that it is expended in muscular motion, since animals that have exerted themselves violently, immediately before confinement in a given quantity of atmospheric air, or during confinement, soonest exhaust it of oxygene; and that, when it is blown into dogs, in the manner veal is blown up by butchers, it produces a remarkable degree of vivacity. These facts, compared with some of the observations, which will be given in the next paragraph, will prove of use in directing us how to apply this air properly as a remedy; especially as they will appear to have been confirmed since their first publication by observations on the sick.

Between unrespirable airs, there seems a remarkable difference in their power to produce insensibility and death. Hydrogene appears the least noxious, both when inspired alone, or mixed with atmospheric air. Azote probably differs little from hydrogene. Hydrocarbonate seems extremely deleterious; Mr. Watt gives evidence of this in the human species. I can add a similar observation. A person in confirmed

firmed consumption breathed a quantity of hydrocarbonate, mixed with 4 times its bulk of atmospheric air : he became very sick, or rather vertiginous ; the pulse was much quickened, and the extremities became very cold. The patient finding an abatement of pain in his side, and of dyspnoea, returned for another dose. The operator, a chemist of great skill, thinking the former dose too strong, mixed 50 c. inches of hydrocarbonate with 600 of atmospheric air. This was respired without any sensible effect. In a quarter of an hour, 100 c. i. of hydrocarbonate were mixed with 600 of atmospheric air. The patient breathed at twice about two-thirds of this mixture, when he was desired to desist. Soon afterwards he became vertiginous and nearly insensible, his pulse at one period being nearly imperceptible ; the sphincter of the bladder was relaxed ; after his recovery, he was again very cold—"intensely cold to his own feelings" was his expression—as well as to the touch. After getting into his carriage, he fainted ; and his pulse for several hours continued quicker and weaker than before. The operator having observed, that when much water is added to red-hot charcoal, carbonic acid air is copiously produced, in the preparation of this last portion of air, had added so little water, that no superfluous steam at all came over ; hence it was as pure as can be made : being also newly prepared, it retained all the charcoal it had carried up ; of which it is well known to deposit part on standing. This might lead to conjecture, that the greater deleterious power of heavy inflammable air from water and hot charcoal (hydrocarbonate) compared with that of light inflammable air, depends on

the

the facility of its combination, or at least of the charcoal it contains with the oxygene of the blood; in consequence of which, it speedily disarms the system of its moving principle. This opinion seems countenanced by the effect of nitrous air, which more quickly destroys life than any of those above-mentioned, and which is well-known very readily to combine with oxygene. Death, in this case, might be more instantaneous, from the instantaneous production of an highly corrosive acid (nitrous acid) and its application to the whole surface of the lungs. But for the rapid effect of carbonic acid air, and the appearances in Sect. XI, I can assign no plausible reason; nor does the above hypothesis suit the facts in Sect. XI; which, with those in Sect. X, refute the opinion of those eminent philosophers, who have of late supposed that water and several bland unrespirable airs occasion death, simply by the exclusion of the oxygene of the atmosphere. Their action is certainly unequal; and I presume, recovery from asphyxia in water (when but little goes down the wind-pipe), hydrogen air, azote, or from strangulation (where no material organic injury is produced), will be much more easy than from asphyxia, occasioned by other unrespirable mediums.

Experiments to discover the effects of the long continued action of aeri-form substances, would be much more curious than such as I have made. They would thus, in all probability, more deeply and permanently affect the living system. If, for instance, an animal were kept in an atmosphere containing $\frac{20}{100}$ $\frac{24}{100}$ of oxygene or still less, it would perhaps be affected by the sea-scurvy. The muscular fibres, at least, and the solids in general would in all probability be found weak,
tender

tender, or easy to be torn. Again, if three equal growing animals were kept, one in the atmosphere, the other in air of an higher, the third of a lower, standard, and in all other respects treated alike ; some considerable difference would perhaps be observed in their growth and vigour.—By frequent immersion in water, the association between the movements of the heart and lungs might perhaps be dissolved ; and an animal be inured to live commodiously for any time under water. If some plan, similar to that which I have ventured to propose, should be executed, such processes of investigation ought to be carried on in the institution.

XIII.—*Some effects of the inspiration of hydrogene, to elucidate the result of the foregoing experiments.*

“ When an animal is immersed in water, *his pulse becomes weak and frequent*, he feels an anxiety about his “ breast, and struggles to relieve it : in these struggles, “ he rises towards the surface of the water, and throws “ out a quantity of air from his lungs. After this, “ *his anxiety increases, his pulse becomes weaker ; the* “ struggles are renewed with more violence ; he rises “ towards the surface again ; throws out more air from “ his lungs, and makes several efforts to inspire ; and “ in some of these efforts, a quantity of water commonly passes into his mouth ; *his skin then becomes* “ *blue, particularly about the face and lips ; his pulse* “ *gradually ceases ; the sphincters are relaxed ;* he falls “ down without sensation, and without motion.” (*Dr. Goodwyn, l. c. pp 3, 4.*) This description of drowning in water applies, as far as the circumstances admit of comparison, to the effects occasioned by the respiration of pure hydrogene. I have remarked them in a num-

ber of healthy persons, who were curious to try how long they could breathe this air. The frequency and debility of pulse, blueness of the lips and coloured parts of the skin, were always observable in a minute, or a minute and an half. Besides, dizziness was felt, and the eyes have grown dim; in animals, the transparent cornea has appeared sunk and shrivelled. Several individuals agree in describing the incipient insensibility as highly agreeable. One consumptive person loved to indulge in it; for this purpose, contrary to my judgment, he used to inspire a cubic foot of hydrogen at a time. This quantity most commonly produced little change in his feelings. Sometimes it brought on almost complete asphyxia. During this process, I have felt the pulse nearly obliterated. Afterwards, as he recovered, it was sensibly fuller, and stronger than before the inspiration. This fact belongs to a general principle now beginning to be understood; when the ordinary powers have been, for a certain time, withheld from the body, they act with greater effect, as holding the fingers to the fire after handling snow, occasions severe aching. For this reason, whenever air with less oxygen is to be inspired, it would seem more advantageous to employ for a long time an atmosphere little reduced, than one so low that it can only be breathed for a short time.

An observation the patient just mentioned made upon himself, seems to shew the necessity of oxygen to muscular action. Judging, from his feelings, that he was perfectly recruited after his dose of pure hydrogen, he has risen from his sofa with an intention to walk about his apartment, but has been surprised on rising, to find himself incapable of advancing three steps,

steps, till he had rested some time longer. In this case, was not the store of loosely combined oxygene, laid in before, expended during the inspiration of the hydrogen, by those motions which are perpetually going on in the system? Did it not require some time to replace the necessary portion in the muscles, remote from the heart and lungs?

XIV.—*Some particulars relative to oxygene, supplemental to the preceding experiments.*

The celebrated Dr. Ingenhousz in a letter dated August 4th 1794, mentions to me a very curious experiment, "which," says he, "if it be a real fact, "throws a great deal of light upon your system; it is "this:—Blister your finger, so as to lay bare the naked and sensible skin. The contact of air will produce pain: put your finger into vital air, and this "will give more pain; introduce it into fixed or azotic air, and the pain will diminish or cease." Dr. Webster, he adds, was informed of these circumstances, by a Frenchman, whose name does not appear: I had often heard them indistinctly related; and it is rather surprising that the fact has not been ascertained. Much of the art of modern surgery consists in keeping the air from wounds and some kinds of ulcers: and this fact, if the account be true, pretty decisively shews which ingredient of the atmosphere is injurious.

I applied a blister an inch long, and half an inch broad, to the back of the third finger of the left hand. When the pain from the action of the cantharides had entirely ceased, I cut away the scarf-skin of the vesication and was sensible, the moment the air was admitted, of a sharp smarting pain. This did not continue

so severe ; but the exposed true skin sensibly smarted. Upon tying the neck of a bladder, containing carbonic acid air from heated chalk, round the root of the finger, the pain very soon subsided. While I kept my finger in carbonic acid air, which was near half an hour, I should not have known it had received any injury. On taking it out, the surface had a whitish appearance — Was this from the beginning of the formation of epidermis ? — In the air — the experiment was made in a warm temperature — the smarting returned ; in an hour the exposed skin was painful and looked angry, as the expression is : I again enclosed it in carbonic acid air ; in six minutes I felt no more pain. After several hours I again removed the bladder, and soon felt the smarting return.

During the hour after my finger had been for the first time taken out of the bladder, I had introduced it into a phial of oxygene air, for a few minutes, but was not sensible of increase of pain ; nor can I say that the redness and angry appearance was owing to this circumstance.

The following experiments were made on three different persons : — 1. The raised epidermis of a blistered finger, after all action of the cantharides had ceased, was cut away in carbonic acid air. No pain was felt. The atmospheric air slowly mixed with the other in the glass cylinder, as I found by the dull manner in which a candle after some minutes burned in it ; and now some slight pain was felt. The finger being put into oxygene air, a smarting came on, and lasted 20 minutes ; but then became less. The finger was next put into air containing alkaline fumes ; and the pain was much severer than ever. — 2. A second blister

blister being opened in the air, smarting pain came on. In a bladder of fixed air it soon went off. — 3. The epidermis was cut off from a blister on my own finger, which I instantly plunged into oxygene air : it felt as when salt is sprinkled on a cut : and the pain was, I am pretty sure, more severe than when my former blister was opened in the atmosphere. In carbonic acid air the pain in two minutes quite subsided, and returned when I exposed the bare skin to the atmosphere.

At Oxford, in 1790, I had proposed to a distressed negro, to try to whiten part of his skin with oxygenated marine acid air. He was to exhibit the appearance, if it should be curious, for the relief of his family. His arm was introduced into a large jar full of this air, and the back of his fingers lay in some water impregnated with it at the bottom of the vessel. It was perceived that he had ulcerations from the itch between his fingers ; and this made me very cautious about the experiments. In 12 minutes he complained of severe pain from the ulcers, and the arm was withdrawn. The back of his fingers had acquired an appearance as if white lead paint had been laid upon them, but this did not prove permanent. A lock of his hair was whitened by this acid. Next day the ulcers became extremely painful, and the hand swelled from the inflammation : this deterred him from a continuance of the experiment after he was cured of his complaint. You cannot safely impute the effect of this powerfully stimulating acid to its oxygene alone.

But the fact stated by Dr. Ingenhoufz is very agreeable to the common phænomena presented by wounds. Moreover, I have lately seen cancerous patients treated by the application of unrespirable air, with the most

astounding success. In mentioning to Dr. Black the introduction of factitious airs into the BATH hospital, as a source of hope, I did not so soon expect an event which ages and nations have desired in vain. Observations, extremely analogous to the experiments just related, were there made during the course of the treatment. See Dr. Ewart's pamphlet. Should it be invidiously observed by any reader of this narrative that something similar had been tried before, it may be truly replied, that these trials were rather discouragements to the new application of elastic fluids; and that failure in former instances enhances the merit of the recent method. Mr. Magellan's case seems never to have been much known in England.

It seems not improbable, that on certain ill-conditioned ulcers, oxygene externally applied has a salutary effect, by occasioning greater action, both of the vessels which throw out the copious thin discharge, and of the absorbents. Many substances, usually applied to such ulcers with success, as metallic salts, contain much oxygene, and some are most highly charged with this principle, as the red oxyds of metals. The following intelligence, if authentic, adds confirmation to this opinion, and may prove useful. A few months ago, I was struck with the frequency of scrophulous tumours among the poor of the county of Longford, in Ireland. Supposing that necessity might have occasioned the trial of many methods of cure, I enquired whether the people there had not some peculiar domestic practices in such complaints. A physician referred me to a simple but very reputable old farmer, as remarkably successful in scrophulous sores. With this person I had an interview. In his practice, he had no view to gain; and that, in his principles, he had nothing of empirical imposture, he convinced me by

by at once disclosing his whole secret. He had himself, many years ago, an ulceration of the submaxillary glands: This, after various unsuccessful applications, was healed by a rustic practitioner like himself. He obtained a knowledge of the remedy, by which, during a long life, he assured me he had himself healed many such ulcers of the glands about the jaws. He was so little speculative, as never to have attempted the cure of an obstinate sore in any other seat. That he might effectually instruct me, he brought specimens of his simples. They were the leaves and stalks of wood-sorrel (*oxalis acetosella*), and the root of meadow-sweet (*Spiraea ulmaria*). The sorrel he prepares by wrapping it in a cabbage leaf, and macerating it by its own juices in warm peat ashes. This pulp is applied as a poultice to the ulcer, and left 24 hours; the application of sorrel is four times repeated; then the roots of the meadow-sweet, bruised and mixed with the four head of efflorescence that appears on butter-milk, left in the churn, are used in the same manner, till the sore heals, which I was told always speedily happens; often in two or three weeks.

The following extract of a letter from Mr. Edgeworth, of Edgeworthstown, contains some supplementary information, and will probably add so much to the credit of my information, as to obtain a trial for the remedy.

“ I have learned from Mr. Mills, that when he was about eight and twenty, he had two large scrophulous swellings in his neck, one under each ear, near the jaw; the marks they had left he shewed me. He was attended by a surgeon in the neighbourhood for some weeks, without receiving any benefit. A farmer, with whom

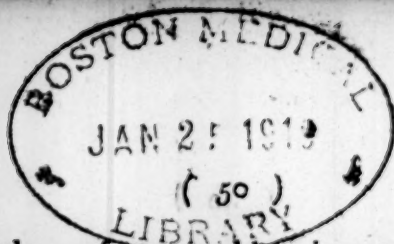
whom he was acquainted, recommended the application he mentioned to you, by which he was completely cured. The man told him the names and quantities of the several ingredients, when he applied them, but did not till some years afterwards (when he was leaving this country for America) apprise him that the *mystery of the cure* (this was his expression) depends entirely upon the sorrel. This person had predicted to Mills, that one of the sores, which had been lanced, would not heal so soon as that which had suppurated of itself; and he found this to be true. Whilst he had scrophulous swellings, he was weak and unhealthy; from the time the wounds were healed, he has been strong and active; he is now eighty; and whilst he was relating these circumstances to me this evening, he kept pace with my horse up hill, for half a mile, without any apparent effort. I mention this, because it is a common opinion (I suppose a vulgar error) that healing such sores is prejudicial to the general health. He has applied this remedy to upwards of an hundred different persons, every one of whom have been cured. — Seven years ago I remember having seen his son, who rents a considerable farm from me, with an enormous scrophulous swelling on his neck; he was in great pain, was weak, and emaciated; he was too impatient to wait for a suppuration of the swelling, and would have the plaister applied to it whilst it was unbroken: the cure was protracted, but it was effectual; he has had no return of the complaint; a slight inequality of surface still remains on his neck; Mr. Mills has communicated his recipe to several, and in particular to a very intelligent person in this neighbourhood, who has employed it with unfailing success. All the patients complain of the severity of the application;

cation ; and in every ulcer to which it is applied, there takes place a remarkable change from a dead pale to a bright scarlet colour." *July 17, 1794.*

This change of colour indicates communication of oxygene, which perhaps the oxalic acid of the sorrel contains in such a state of combination as easily to part with a portion. Now Dr. Darmin, in his *ZOONOMIA*, attributes scrophulous swellings of the glands to inirritability, which, as I have conjectured, may arise from a certain deficiency of oxygene. These principles would supply an obvious theory, were we but certain of our facts. If however, as the preceding account implies, sorrel produces detumescence of the glands before suppuration, its application will be, I suppose, a more eligible practice than any now in use. Writers in the *Materia Medica* may have applied *deobstruent* — their word of course — to this plant, but I remember no particular commemoration of its virtue in scrophula. Murray, a compiler of extensive reading has nothing to this purpose. — (*Apparat. Medicam.* III. 492-9). — Since the second edition of this pamphlet, the Rev. Joseph Townshend has successfully applied the sorrel to scrophulous ulcers, of which trial an account will appear in the 2nd vol. of his *Guide to Health*. I suppose juice of lemon, more or less diluted, would produce the same effect.

XV. — *Of the preparation of atmospheres of different standards.*

Perspicuity in the directions, which cannot for all readers be attained in *reasonings*, being a principal object



object in the present pamphlet, it may be useful, before I proceed, to exhibit a view of those mixtures which furnish atmospheres of an higher or lower standard, than the common air. By an *higher standard*, I mean more than 28 parts of oxygene in 100; by a *lower standard*, less. For the sake of brevity, we might say, *air of the standard of thirty six*, instead of "air containing thirty-six parts of oxygene in an hundred parts."

Mr. Watt's hydraulic bellows furnish the means of throwing any proportions you please of the different airs into the common reservoir. I have found a small spare hydraulic bellows—of the contents of a gallon for instance—highly useful in adjusting the proportion of atmospheric air. It may be larger; but when small, it is very *handy*. The effect, as far as can be ever useful in practice, is shewn in the following tables:

Change of the standard of atmospheric air, by addition of other airs.

The standard of atmospheric air being 28 oxygene 72 azote, it is altered in this manner, by the addition of successive equal parts of atmospheric to one of oxygene: Small fractions are neglected.

				<i>Oxygene. Azotic.</i>	
1 part of atmospheric to 1 of oxygene -	64	-	36		
2 of atm. - - to do. - -	52	-	48		
3 do. - - to do. - -	46	-	54		
4 do. - - to do. - -	42	-	58		
5 do. - - to do. - -	40	-	60		
6 do. - - to do. - -	38	-	62		
7 do. - - to do. - -	37	-	63		
				3 do.	

8 do.	- -	to do.	- -	36 - 64
9 do.	- -	to do.	- -	35 - 65
10 do.	- -	to do.	- -	34 $\frac{1}{2}$ - 65 $\frac{1}{2}$
11 do.	- -	to do.	- -	34 - 66
19 do.	- -	to do.	- -	30 $\frac{1}{2}$ - 69 $\frac{1}{2}$

The standard is altered in the following manner by addition of successive equal parts of oxygene to one of atmospheric air :

				<i>Oxygene.</i>	<i>Azotic.</i>
2 oxygene	- -	to 1 atmospheric	76 - 24		
3 oxygene	- -	to do.	81 - 19		
4 do.	- -	to do.	85 - 15		
5 do.	- -	to do.	88 - 12		

Respecting these two tables, it is to be observed, that the most skilful chemists have never been able to obtain oxygene air quite pure ; it may therefore be allowed, that in such as will commonly be prepared, not more than 85 parts in 100 will be pure oxygene ; unless it be prepared from good manganese and rectified vitriolic acid ; of this, washed in lime-water, not 10 parts in 100 will be unrespirable. The unrespirable air, with tolerable care, will be obtained free from oxygene. The following proportions, therefore, will be more exact than the foregoing :

Effect of the addition of different portions of atmospheric to one of unrespirable air.

				<i>Oxygene.</i>	<i>Unrespir.</i>
1 atmospheric	-	to 1 unrespirable,	14 - 86		
2 do.	- -	to do.	19 - 81		
3 do.	- -	to do.	21 - 79		
					4 do.

4 do.	-	-	to do.	-	-	22	-	78
5 do.	-	-	to do.	-	-	23	-	77
6 do.	-	-	to do.	-	-	24	-	76
7 do.	-	-	to do.	-	-	24	-	76
8 do.	-	-	to do.	-	-	25	-	75
9 do.	-	-	to do.	-	-	25	-	75
10 do.	-	-	to do.	-	-	25½	-	74½

Effect of the addition of different portions of unrespirable airs to one of atmospheric.

1 atmospheric	-	to 2 unrespirable	9	-	91
1 do.	-	to 3 do.	7	-	93
1 do.	-	to 4 do.	5½	-	94½
1 do.	-	to 5 do.	5	-	95

XVI.—*Of the method of procuring elastic fluids.*

To procure a dose of factitious air by means of Mr. Watt's apparatus will, I think, be found more easy than to dress a joint of meat. In several instances under my eye, a servant of plain understanding has managed the apparatus perfectly: in one a maid servant has proved quite equal to the task. When inexperienced operators have failed, it has been from setting the water to drop before the charge in the furnace was red-hot, or letting it drop too fast afterwards. Hence they get steam instead of air. When the joints are made tight, and the heat is proper, and the water does not drop too fast, the operation proceeds perfectly. Mr. Watt gives a sufficient variety of lutes. A strip of oiled silk bound fast round a joint, alone makes a good lute, so does a strip of bladder.

I was for some time anxious concerning oxygene air. Expecting this would be full as extensively useful in medicine, as any unrespirable air, I wished for a method

method equally simple of procuring it. The manganese from the Mendip hills gives 1. azotic, 2. oxygene, 3. azotic with carbonic acid air; so that the whole product is not much superior to the atmosphere. I feared lest it should be found difficult to catch the best part of the produce. At the suggestion of Mr. Hermbslaedt and Mr. Chaptal I turned my attention to the solution of manganese in vitriolic acid. Mr. Hermbslaedt had found a pound of either the Ilfeld or Ilmenau manganese, with strong vitriolic acid, to yield 3384 cubic inches of "the best oxygene air."—(*Hermbslaedt's Versuche*, B. II. p. 49.) Mr. Chaptal obtained full as much from French manganese. I procured 150---200 c. i. of oxygene air (which by the nitrous test proved excellent) from oil of vitriol and 1 oz. Exeter manganese. But when I came to make experiments with a view to discover a proper method for common practice, I perceived that this process was highly objectionable. The first portions of air procured by means of the oil of vitriol of commerce contained much oxygenated marine acid air—a species of elastic fluid exceedingly deleterious and irritating to the lungs. This happened because ordinary oil of vitriol is contaminated with muriatic acid. Besides, as the acid of vitriol will itself be carried up by the heat necessary to extricate the air by this operation, the vessels will suffer from corrosion, unless troublesome precautions are employed. The air itself too will not easily be totally freed from the pernicious acid fumes. Hence, contrary to my first intention, I shall omit directions for procuring oxygene air from oil of vitriol and manganese; they are fortunately become unnecessary, since Mr. Watt's apparatus answers incomparably for this also, according to his last directions.

Exeter

Exeter manganese is in no respect preferable to any other, that does not contain much calcareous earth, or some noxious mineral, which latter is not the case with any manganese I know. To impregnate hydrogen air with zinc, I have thought it sufficient to put a few ounces of zinc (which in the shops is called *speltre*) into the pot, the rest of the charge being of iron.

It may be well to suffer oxygen air to stand some hours before it is used, that it may deposit the suspended particles of manganese; which however, as far as I have seen or heard, have never been in the smallest degree hurtful. — As to the hydrocarbonate, I fully agree with a very judicious correspondent, that it will be most powerful when fresh. When the fire-tubes are new, hydrogen will be generated as well as hydrocarbonate.

As there can be no reasonable doubt but the ulcers of the lungs were healed by air from chalk and acids in the case of the lady described by Dr. Ewart, and as other respectable observers have seen the symptoms of consumption alleviated by the same practice, I have added to this edition the figure of an apparatus for effervescing mixtures, less objectionable in one respect than I remember to have seen described. It may be used as an auxiliary to Mr. Watt's apparatus, but ought in no case to be depended on alone. The lower vessel *B. fig. 1. pl. 4.* is to contain vitriolic acid or spirit of salt (muriatic acid) and chalk for carbonic acid air; and either acid with zinc for hydrogen air. The former of these mixtures foams much, and the apparatus should be placed on a large pewter dish. The oil of vitriol should be mixed with 16 or 20 times its bulk of water; and the chalk should be pounded and made
into

into saufages with water. The vessel should be filled only to a 4th or 5th part of its height with the materials. It may be made to hold from three to five gallons. Into the small bucket C of the capital may be put spirits of hartshorn to the depth of an inch, the bucket itself being four inches deep. The fumes of the spirit of hartshorn will arrest the acid spray, and prevent its passing down the long tube. The capital A is to be set in the groove at the top of the vessel B, which is to be filled with water. This groove should be more than an inch deep. The tube may then be turned towards the patient's face. Spirit of salt diluted just enough to dissolve the chalk with moderate briskness is better than vitriolic acid for a continued effervescence ; but it is more expensive ; for this acid the chalk need only be broken into lumps of the size of a walnut. The spirit of hartshorn should be renewed whenever it has considerably lost of its pungent smell.

If hydrogene air be wanted, the vessel B may be filled to a greater height, because the ingredients do not foam so much. The oil of vitriol in this case is not to be so much diluted ; from 5 to 7 times its bulk of water is sufficient. But it may always be tried in a glass with a bit of zinc beforehand. You will easily judge whether your mixture wants acid or the other material according as it begins to act anew when you add a little of one or the other. If you drop in a roll of chalk, for instance, and no hissing is perceived, it wants acid. The whole apparatus should be japanned, and the inside also be anointed with melted bees wax. I have directed, when it could be done, that the vitriolic acid and water should be boiled together. The
management

management of this apparatus is troublesome, as of every other where you want a continued effefferescence. In pouring these acids from vessel to vessel, it is difficult to avoid some splashing, by which holes will be burned in the cloaths. The fumes of muriatic acid soon spoil polished iron furniture.

XVII. — *Cases in which oxygene air was inspired.*

The clearest directions for the use of factitious airs in medicine will be afforded by a faithful account of the effects they have been already found to produce. I shall therefore dispose the clinical observations I have to lay before the reader in the best order I can devise. To these observations I shall subjoin a brief recapitulation; in hopes it may furnish a more precise idea of the progress already made, and contribute towards the accumulation of further knowledge.

Letter from DR. THORNTON.

Feb. 27, 1795. — *Great Russell-street.*

DEAR SIR,

I am very happy to hear your proposal for a *pneumatic institution* meets with the support of so many eminent physicians and men of science. I wait with the utmost impatience for its establishment, firmly believing that the experience resulting from it will be of the greatest public utility. The subjoined cases will be a great inducement for extending pneumatic remedies in the proposed institution to surgery; they will, I trust, operate somewhat with the public in promoting a subscription sufficient for that benevolent purpose.

The

The first case will appear to great advantage, as the patient has obligingly permitted me to enclose to you his journal, which is the faithful picture of his own feelings; he assures me, he had not the least knowledge of any part of your *theory* of the operation of vital air, but was induced from seeing somewhat similar cures performed, to confide himself to Mr. Hill, an ingenious surgeon, who has been among the first to apply these new powers to the purposes of his profession.

Journal of the Rev. Mr. ATWOOD, Rector of Saxlingham and Sharrington. Part I. Statement of the case, and of the effect of the common means of cure.

" December, 1779. — The left leg has felt for some time past very heavy; is now much swelled; upon pressure the indentation continues. This was wholly removed in about nine weeks by means of a very tight bandage on the leg, exercise, spirituous lotions, fumigations, and frictions. — October, 1780. The constitution much impaired by the hot climate of Spain; was attacked with jaundice, which yielded to slow journeys on mules and to oranges. — January, 1785. My health was much deranged during this month, with great debility. — 1786 and 1787. The habit much relaxed. — December, 1788. Had violent night sweats. — January, 1789. These continued to the latter end of this month. — May, 1789. Had a violent inflammatory fever. — August, 1790. Had an eruption on the surface on the body. — 1791. During this whole year, experienced great debility. — March, 1792. Was seized with an inflammatory fever, attended with delirium. — May, 1792. Had a third attack. My physician ordered me sea-bathing, to remove the extreme
E
debility

debility which succeeded to this fever.—From August 1792, to February 1793, bathed in the sea. During this time I had many dreadful spasms in the stomach and bowels, accompanied with nausea and vomiting. These were the forerunners of the disease, which has since affected my left leg.—January, 1793. There appeared a *mahogany coloured* swelling in the left angle of the left leg, which kept up an incessant gnawing pain.—July, 1793. This hardness was attempted to be eat away with caustic; but it produced only an ulcer of a very unfavourable aspect.—September, 1793. I placed myself under a most skillful surgeon at Norwich, who applied fomentation, unguents, &c. but without any material benefit.—November, 1793. Though a cripple, was enjoined regular exercise. The ulcer, however, still continued increasing. January, 1794. A *new enemy* more formidable than the other made its appearance. It had the same *dark mahogany colour*, and the same *unconquerable hardness*. By degrees this formed into a dreadful ulcer, which increased daily.—March, 1794.—Came to London, and placed myself under a surgeon of great eminence. Was attended by him daily with unremitting attention. Twice did he employ the lapis infernalis, but these ulcers seemed to resist every application. My constitution being extremely debilitated, with loss of appetite; want of sound sleep; and the mind exceedingly irritable, sea-bathing was once more enjoined.—From June 14, to October 18, bathed in the sea.—June 27. Mortification took place. The usual methods, bark in great quantities, port wine, and yeast poultices, were had recourse to.—October 25. Returned to London. The pains in the leg were excessive; the sœtor intolerable;

lerable; the ulcers had made great encroachments; frequent nausea at the stomach; the bark and other medicines were frequently rejected, the breakfast sometimes, and now and then the dinner; the nights were excessive bad; strength impaired; in short every thing was unfavourable. — December. A friend who had seen the whole progress of the case, asked my surgeon, “ what prospect there was of saving the limb.” He made no reply, but very gravely shook his head.

The following letter is here introduced as essential to a complete idea of the case.

Barnet, Feb. 25, 1795.

DEAR SIR,

Being accidentally present at the first interview between you, Mr. Hill, and Mr. Atwood, I cannot help expressing my great *astonishment* on finding so speedy a cure has been actually effected in so desperate a case.

The wound, I mean what particularly called my attention at the time, appeared to me to extend *four* inches in longitudinal direction of the muscles of the leg, and about *three* inches transversely. It was so *deep* that not only the whole thickness of the adipose membrane was destroyed, but a considerable loss of substance had taken place in the muscular parts themselves.

The ulcer was in appearance as *ill-conditioned* as I remember to have seen, either in the London hospital, or in my own practice of near thirty years, affording an ichorous foetid discharge, which appeared to inflame the surrounding parts, and which must therefore have gone on increasing the evil.

The gentleman's habit of body, from his own account, was such (for he had tried bark, sea-bathing, &c. without benefit) that I confess I had not the most distant idea, that any cure could have been performed, much less in so short a space of time.

Indeed I think it a great happiness to mankind in general, that such a remedy as the vital air has been discovered, and that men of science are employing it: I am rejoiced to have such proof, that the blood and juices of our fellow creatures can be so changed, that we need not *now* despair of our patients even in situations truly deplorable. I have the honor to be, &c. &c.

(To Dr. Thornton.)

JOHN CORP.

PART II. *of Mr. ATWOOD's Journal, beginning the day before the inhalation of vital air.*

December 13. Got up with a peculiar sensation of weight and pain in the leg; a sense of nausea at the stomach; and no inclination for breakfast; spirits oppressed; and the mind irritable; when endeavouring to walk, felt great pain; the large ulcer in the leg looked of a blackish hue in places; a probe being thrust into one part of the ulcer, I had not the least sensation in that part; yeast poultices were talked of; had no appetite for dinner; felt very much indisposed towards the evening; no inclination for supper; had a sense of chilliness on first getting into bed, succeeded by hot palms; passed as usual a bad night, with perturbed sleep; awoke at two o'clock with sharp and burning pains in the leg, which continued until five in the morning; dosed till nine. — December 14. Got

up with nausea at the stomach ; and a sense of languor ; no appetite for breakfast ; spirits exceedingly oppressed ; for the first time inhaled the VITAL AIR diluted with a portion of atmospheric ; had a pleasurable glow at the time ; felt an appetite for dinner, and my friends observed my cheeks did not flush after dinner, as heretofore ; my spirits, which were somewhat better during the day, sunk towards the evening ; no inclination for supper ; passed a very indifferent night. — December 15. Got up but without a sense of nausea ; had a slight inclination for breakfast ; perfect ease in the leg ; inhaled again the vital air ; felt a great appetite for dinner, and a peculiar pleasurable lightness after dinner, as if no sustenance had been thrown in ; with a flow of spirits ; and a strange idea of being able to mount a horse, and ride as fast as people in health ; appetite for supper ; passed the sweetest night ! such as I am sure I have not enjoyed these four years. — December 16. Got up quite refreshed, without the least sense of nausea at the stomach ; a great inclination for breakfast ; spirits unusually elated ; took the vital air ; felt a genial glow during the whole day ; great appetite for dinner ; walked with agility and without pain ; the wound however appeared unfavorable to-day ; appetite for supper ; a good night ; awoke with a thick clammy perspiration. — December 17. Spirits much depressed ; no inclination for breakfast ; mind very irritable ; much pain in the wound ; inhaled the vital air ; the wound threw off *nine sloughs* this day ; a slight appetite for dinner ; the spirits recovered towards the evening ; inclination for supper ; had a sound night's rest. — December 18. Appetite for breakfast ; inhaled the vital air ; a sense

of glow, which extended even to the fingers ends; the muscular powers were evidently increased; walked with slight, or no pain.—December 19. The wound for the first time discharged *real pus*; had the *sensation*, if the expression can be allowed, of *perfect health*, never experienced before this week; sleep very sound; pains in the leg towards morning.—Dec. 20. Got up with great spirits; inhaled the vital air; the wound discharged a great quantity of real pus; a craving for dinner; felt no longer an inclination for much wine, and after four glasses, had the same satisfaction, as three pints used formerly to produce; porter was now rather coveted; spirits elevated in an extraordinary degree, which together with a genial summer's warmth continued from four to nine in the evening, and then subsided to humbler spirits; slept profoundly from ten to four, which, with the morning doze, made me get up sufficiently refreshed; transitory pains in the leg.—December 21. A fine appearance of *white edges* in the wounds; great appetite for dinner; an universal glow in bed, accompanied with perspiration; sharp twitching in the leg.—December 22. Appetite for breakfast; inhaled the vital air; the wound still kept on a great discharge of laudable pus; no appetite for dinner; in the evening a peculiar sense of weight and uneasiness in the leg; a great listlessness in the evening; much irritation in the leg, particularly in the ulcer, with much *itching* round the part; but an indifferent night.—December 23. Spirits oppressed; inhaled the vital air; returned home without much inclination for dinner; spirits rather mended towards evening; enjoyed a good night's rest.—December 24. Eat a hearty breakfast; spirits elevated;

vated; walked with ease and vigour; a surprising change for the better had evidently taken place in the wound; appetite for dinner; had a good night.—Christmas day. Still the same happy appearance in the wound to day.—December 27. The ulcer looked wonderfully well; was evidently decreased in size; the discharge very favourable; but less in quantity; great pain was felt in the ulcer for a quarter of an hour in bed; afterwards fell into a refreshing sleep.—December 28. All the appearance of healing; the wound much decreased; some parts filled up; and the borders of a fine white; the whole leg, which before exhibited a dark purplish appearance, wore now the livery of health.—December 29. The cavity of the wound was almost filled up; the effects of the vital air operating together with my amendment, produced a constant gaiety, as if I had been drinking champagne; enjoyed a profound night's rest.—December 30 and 31. The same sensation of perfect health; elevated spirits; great appetite; and comfortable sleep.—New-year's day. Every thing in a good train. My toast after dinner was, "*May the introducers of aerial remedies meet with that recompence from their country, which they so amply deserve.*"

[This toast from motives of delicacy I would have omitted, but I thought it my duty to transmit you the journal entire as written by the author. R. I. T.]

It was applauded and unanimously drank.—Jan. 1, 2, 3, 4, 5, 6, 7. As on the preceding days, with evident and progressive amendment in the wound.—January 8. Went to a private concert; before, music was disgusting to me, having no spirits to enjoy it; was surprized,

surprized to find myself standing, as I was playing on my violin, without leaning on a chair, at several different times during the evening, and without the least sensation of fatigue or pain.—January 9. The smaller ulcer, which of late I have not much noticed, was *healed*.—January 10, 11, 12, Nothing peculiar.—January 13. The old ulcer was this day rubbed hard with a flannel, and the larger ulcer appeared nearly healed.—January 14. Walked with great vigour; the larger ulcer was rapidly *skinning over*; appetite good; spirits good; and sleep the same.—January 17. Notwithstanding the season, the most inclement I remember, the ulcer was completely *skinned over*: and my body seemed fortified against cold.”

Here ends the journal. I have to add that on the 25th of February, the family received a letter from Mr. Attwood, from on board the *Stately*, of which ship he was made chaplain. He was then in perfect health and spirits.

Letter of MR. ATWOOD to DR. THORNTON.

*Symon's Town, Cape of Good Hope,
15th Sept. 1795.*

MY DEAR SIR,

I ardently wish to enjoy the happiness of seeing you again. You have performed wonders on my peculiar constitution, radically strong and powerful, but which was hastening to a rapid dissolution, till revived and renovated by the oxygen. My strength is encreasing every day with a firmness of nerve and calmness of spirits never experienced before. I persevere in an uniform plan of rising at six, walking till eight, sub-

sisting

lifting on soup, fish, and vegetables, and going to bed at ten. Wine is left off (except three glasses of white Teneriffe wine at dinner), as well as meat. By these means I feel the habit cool and braced, with a capability of taking powerful exercise, without the least fatigue. The fleecy waistcoats are absolutely necessary in this climate, as heavy dews and cold winds at sunset often succeed the heat of the day. The prevailing disorders of course are fevers, flux, and dysentery, which destroy many patients; except this sudden check to perspiration the climate is delicious, but in my opinion not so hot as Lisbon. Last June (December here), green peas were in blossom.

With the greatest esteem,

I remain, &c.

T. E. ATWOOD.

There are two other cures, which deserve your particular attention, as the persons were previously in the best hands, and as they serve in some degree to confirm your ideas respecting *herpes*, as depending upon a deficiency of the oxygenous principle.

John Patterfon, aged 45, married, has five children; he was formerly a sailor. He had endured much hardship, and at one time lived for nine months wholly on salt provisions. He was subject from the age of fourteen to eruptions on his face. When he came under Mr. Hill's care, I saw him, with a face encrusted over with humours, several purple blotches on his body, many hard scales or scurffs about his arms, and a dark-coloured

coloured deep ulcer in his leg, which gave out an ichorous and foetid discharge. He had also lost his sight near eighteen months. These complicated evils had resisted the well-known abilities of Messrs. West, Carr, Turnbull, Wathen, Phipps, and others. This case being recommended to Mr. Hill by the last named gentleman, he gave him the vital air blended with atmospheric air, as an alterative of the blood, strengthening his constitution with chamomile tea and bark, and Mr. Phipps continued those applications to the eyes, which before the purification of the blood, proved unsuccessful. After a few weeks inhalation of the modified atmosphere, I had the satisfaction of seeing him with a face perfectly clear and smooth; large white scales fell from his hands and arms; the dark purple ulcers on his body, and the vitiated ulcer in his leg, were healed; and he had so far recovered his sight, that he had at first a blue, then a brighter light before him, and after a regular attendance during four months he was able to discriminate different objects in the street.

The subject of the next case is a widow lady. She had a humour in her right leg, which deprived her of exercise, and had produced a painful and discoloured sore in that part of above 18 years standing; 4 years of which time she was attended by Pott, and twenty-seven months by Sharp; but neither of these eminent surgeons were able to effect a cure. After only three week's inhalation of the vital air, a violent itching came on, and in another week this leg was rendered as sound as the other. Mr. Sharp saw this patient at Mr. Hill's, and examined her leg, and was very much delighted. This lady has now continued well near six months.

I need

I need not take up your time with Mr. Hill's success in other less conspicuous cases. What I have already related is sufficient to set forth the advantage that will probably arise to surgery from the introduction and proper application of the pneumatic practice.

I am, &c. &c.

R. I. THORNTON.

P. S. Nothing is said of dressings in the above cases; the usual modes having been practised. The body too was kept open, as occasion required. — It may be interesting to add, that the young lady, related to an eminent surgeon in London, whose case is mentioned in a letter of mine which you published some time ago, is now perfectly well. The violent spasmodic seizures yielded completely to oxygene air. In the same collection I mentioned the case of a gentleman far gone in pulmonary consumption, whose symptoms were surprisingly mitigated by a lowered atmosphere. Finding himself recruited, he undertook a journey of 140 miles. The hectic fever returned, perhaps in consequence of his breathing the purer air of the country; and in week after his arrival among his friends, he paid the debt to nature. — R. I. T.

It would be desirable that Dr. Thornton should fully state the case of the lady afflicted by spasms. The cure, I understand, was so compleat, that it gained the good-will of several medical friends of the patient to the pneumatic practice. The case, if I conceive it rightly, was similar to those described in *Zoonomia*, p. 26.

Letter

Letter from MR. BARR.

Birmingham, 14th March, 1795.

DEAR SIR,

Having a very high opinion of the effects to be expected from the practice which you have so benevolently promoted ; and wishing to encourage farther experiments upon a subject so interesting to humanity, I take the liberty to communicate to you some observations which I have made on the effects of different facitious airs in the cure of scrophula,

About four months ago, a gentleman of this neighbourhood applied to me for advice in the management of a scrophulous ulcer of considerable extent. He had tried various remedies, but had derived no lasting advantage from any of them. When I first visited him he was worn down by a long course of night watching. The deep-seated pain of the arm was so constant and severe, that it had in a great measure deprived him of sleep. His countenance was pale and sickly ; his limbs were continually afflicted with aching pains ; every exertion, even the most gentle, seemed beyond the measure of his strength, for his body had lost much of its active power, and his mind much of its wonted energy. The discharge from the ulcer was copious, thin, bloody and corrosive ; and besides, the whole surface of the sore was so exceedingly irritable that the mildest dressings, applied in the gentlest manner, produced very severe and lasting pain. During the first six weeks of my attendance he regularly took as much Peruvian bark in substance as his stomach and bowels could

could bear ; and the ulcer was dressed with various emollient, sedative, and astringent applications, but without any permanent advantage. I then recommended a trial of oxygene air, which was readily complied with. He began by inspiring four ale quarts diluted with sixteen of atmospheric air twice a day, and gradually increased the quantity of oxygene to a cubic foot and a half in the day ; by pursuing this plan for about a month, his health was wonderfully improved, but the ulcer shewed no disposition to heal. The deep seated pain was now entirely removed, but in the space of a few days more, he complained of a burning sensation over the whole surface of the sore, similar to the pain arising from erysipelatous inflammation. This unpleasant sensation first commenced after inspiring the whole quantity of oxygene in the space of two hours, which before had been taken in equally divided portions morning and evening. We still pursued our plan, thinking that this new pain might be owing to some accidental circumstance, and that it would soon pass away. But it every day continued to increase, and the ulcer began to spread wider and wider. The edges became thick and were turned outwards, and the discharge became more thin and acrid.

In this situation, a local application seemed proper. I wished to have applied hydrocarbonate externally to the ulcer, but this from some circumstances of the case was not practicable. I then thought to moderate the stimulus of the oxygene by a mixture of hydrocarbonate, which Mr. Watt told me would occasion no chemical change in the two airs. Accordingly a mixture of three parts of oxygene, and one of hydrocarbonate was prescribed. Four quarts of this mixed air were

were added to about sixteen of atmospheric, and this quantity inspired morning and evening. In less than a week the burning sensation was much diminished, and the ulcer put on a more healing appearance. The mixed air was then increased to five quarts, and used as before, which produced an increase of all the pleasant symptoms. After a few days trial of this proportion of the mixed air six quarts were prescribed. This is the quantity now inspired morning and evening.

My friend, at present, enjoys good health and a good appetite, and feels himself as strong as at any former period of his life. The ulcer is now reduced to less than half its original size, and healing rapidly. There is neither superficial nor deep seated pain remaining, and the motion of the joint, and the action of the contiguous muscles are free and easy.

I am, dear Sir, &c. &c.

JOHN BARR.

P.S. The event I will take care to communicate, not doubting but you will find an opportunity of laying it before the public at no great distance of time.

Extracts of Letters from Dr. CARMICHAEL.

SIR,

I take the liberty of sending you the following lines, wherein I shall briefly state the effects produced by oxygene upon a person affected with amaurosis. My patient I. B. aged 45, began 15 months since gradually to lose his sight, so that about 5 weeks ago he could scarcely

scarcely distinguish a bright fire, or even the glare of the noon day sun. The right side of his face, and half of his tongue, are affected with numbness, coldness, and loss of feeling. No other complaint, P. 84. In this state he began on the first of Dececember, 1794, to breathe a mixture of 1 part of oxygene obtained by heat from manganese, and nine parts of atmospheric air, for about the space of five minutes.—2d of December: Has passed rather a restless night, and complains much of heat and itching of his neck and shoulders. —P. 90. Breathed a mixture of 1 to 7. — 3d. A very restless night. Complains much of pain in his temples and forehead.—P 98. I directed 8 ounces of blood to be taken from his arm, and afterwards to breathe as yesterday.—4th. The blood drawn was remarkably dark in appearance, and after some time contracted a thin superficial florid crust.—P. 88. Passed a very restless evening and night. Head-ache not quite so severe. Breathed a mixture of 1 part ox. to 4 atm.—7th. Very severe head-ache, with temporary loss of the use of his lower extremities. — P. 100. T. white. I directed the venæsection to be repeated to 12 ounces. This day I was afraid to give him any of the modified air. —8th Has passed a better night, but feels himself low and feeble.— P. 92. Blood dark ; but sooner than formerly assumed a florid crust. Inhales as before.—10. Has passed two restless nights, head-ache severe, but to use his own expression, he feels himself "lightfomer." Breathed equal parts.—12th. Both nights he has had very severe head ache : and on the 11th was for some little time deprived of the power of motion. Numbness and coldness of his cheek and tongue continued. The irritability of the pupils is not at all increased.

Here

Here I thought fit to give up the use of the oxygenæ, as by a continuance of it, I must confess I had fears of inducing a more serious disease than that I was endeavouring to remove or alleviate.—14th December. As I did not think it prudent to persist longer with the ox. I determined to make trial of the hydro-carbonate. I directed for him a mixture containing 1 quart of that species of factitious air, and 19 of atmospheric air, which he inhaled in about ten minutes, resting at intervals. The same quantity was repeated for four successive mornings, but no advantage attending this mode, and the vertigo occasioned by it being troublesome, I did not wish to continue the use of it for a longer time. From its discontinuance till the evening of the 27th December, he continued much in his usual way, when he was attacked with apoplexy, from which however he gradually recovered.

Another case of Gutta Serena has afforded me an opportunity of trying the virtues of oxygenæ. This patient, about forty years of age, and of a very irritable habit, has been gradually losing her sight for two years past; that of one eye is nearly gone, that of the other very indistinct. The nerve of the right eye has almost entirely lost its irritability, but the pupil of the left still contracts pretty readily on the approach of light. On inspection the slightest degree of cloudiness towards the external canthus of the left eye may be perceived: and she describes objects as seen by the edge of a wall, or of any other interposing medium. Every other day, objects appear to her tinged with a yellow hue, and on the intermediate ones of a dark purple. She has the same sense of colours in the dark and when

when the palpebræ are shut : those appearances have succeeded each other at the interval of 24 hours, with the utmost regularity for some months past. At times she is subject to a total loss of sight, which, however, continues but for a few minutes, and seldom longer than an hour at a time. Its return is in general accompanied by a considerable discharge of flatus from the stomach, to which she is at all times subject. She has tried many remedies, but her sight, she says, has been getting gradually more imperfect.

14th January 1795, I directed her to inhale a mixture, containing 6 quarts of ox. procured from Exeter manganese by heat only, and about 18 of common air, which she did in the space of 5 or 6 minutes; and repeated it daily till the 22d.—22. No perceptible change. It was suggested that it might be better to divide the dose, and repeat it twice a day, which was accordingly done. I directed her to take 3 quarts of ox. diluted with 18 of atmospheric air, forenoons and evenings. As she was rather costive, she took occasionally of the Edinburgh stomachic pill.—2d Feb. No advantage attending this method, the dose was increased to 6 quarts of ox. diluted as above, mornings and evenings. On the morning of the sixth she awoke completely blind, and continued so with the exception of a few momentary intervals during the day; she however passed a good night, and on the morning of the 7th found her sight much in the same state as it had been on the evening of the 5th. She was a good deal alarmed at the deprivation of sight for so long a period; and as she had not derived any advantage from the use of the modified air, I desired her to discontinue it. Her vision became gradually more imperfect, her
F pulse

pulse, during the time she inhaled the modified air, in my opinion, rather acquired tension, and the irritability of her system was not quite so apparent.

S. P. *Æt.* 17 $\frac{1}{4}$.—Complains of universal languor and debility, palpitation and difficulty of breathing on the slightest exertion, especially in going up stairs; she is much emaciated, and her skin is universally pale; her feet and ankles for some months past have become œdematous toward evening, but more particularly after using exercise; she complains of pain of her stomach, and of frequent cough, attended at times with pain of her side. B. regular; app. impaired; pulse 112. She has never menstruated, nor had any of the symptoms usually preceding that evacuation. She first began to complain about 2 $\frac{1}{2}$ years ago; since which time she has taken different medicines, but without advantage.—Feb. 14, 1795, I directed her to inhale daily a mixture of oxygene and atmospheric air, in the proportions of 3 to 17.—18. Modified air produced no evident effect. I directed her 6 quarts of oxygene diluted with 14 of common air.—23d. Since the proportion of oxygene was augmented, her nights have been restless, and she has complained of general heat. Cough more frequent; p. 125.—26th. Her evenings and nights are still restless; cough increased; pain of her stomach not abated; p. from 120 to 125. I directed her to use the modified air in the proportions at first prescribed.—March 1. Sleeps better, and in the evenings she thinks that she is less hot. Cough less frequent, pain of her stomach not abated; p. 110.—6th. Pain of her stomach less troublesome, appetite mended;

mended ; thinks that her spirits are higher than usual ; and that she feels less fatigue and dyspnœa on motion, p. 100.—The appearance of her countenance is evidently more healthy ; cough much less frequent ; dyspnœa and palpitation on motion much relieved ; p. 98. sleeps well ; œdema of her feet and ancles seldom returns in the evenings, excepting after more than usual fatigue.—15th. Continues to recover in every respect ; cough nearly gone ; no return of pain of her stomach for some days ; complains so little of dyspnœa and palpitation on motion, that she can walk a mile and upwards without being particularly affected by either, and without much fatigue ; p. 89. — 20th. Her general health much improved ; the universal paleness of her skin has given way to the natural appearance ; and her cheeks, lips and nails have acquired a rosy tinge ; p. 81. She has not yet menstruated, nor has she hitherto had any signs indicative of such a change ; but as that discharge depends upon a certain tone of the arterial system in general, I have little doubt but that it will be established with the complete restoration of her health ; which desirable event there is every reason to believe is at no great distance.

I am, &c. &c.

JOHN CARMICHAEL.

28th. Has uniformly mended in appearance, strength, and in respect to her own feelings.—J. C.

Birmingham, March, 1795.

Extract of a Letter from DR. PEARSON.

DEAR SIR,

: In my little publication, I can scarcely call any thing my own, but the observations on the *vapour of æther*, of the probable use of which in phthical cases, your considerations on factitious airs first gave me the idea. As the number of consumptive persons in this large manufacturing town is deplorably great, I have had frequent opportunities of trying the inhalation of æther in such cases; and I have the satisfaction to say that I have found it very beneficial. It abates the hectic heat, relieves and often removes the dyspnoea, and promotes and improves the expectoration. It seems to have such an effect as a mixture of inflammable and fixed air (duly diluted with common air) would have; and where the factitious airs cannot be had, it may be used in their stead with great advantage.

My trials with inflammable air upon consumptive patients at the hospital here, have, as yet, been too few, and those too much interrupted, to admit of any certain conclusion; but I have lately had a proof of the salutary operation of oxygene air in the case of a chlorotic girl, Mary Rider, 22 years of age, who has had her menses suppressed for the last 12 months. After she had taken for many weeks the usual emmenagogue medicines without experiencing the smallest benefit, I ordered her, at the end of December, oxygene air, of which she took a large dose, immediately after it was expelled from oxygene, and before it had time to make any deposit. Her pulse, which before was very languid, was considerably raised by it; and she said she felt a warmth in her chest, which continued

tinued throughout the day, accompanied with head-ach and an uneasy sensation at the stomach. At the 2d application, about a fortnight afterwards, she inhaled a smaller dose (viz. two quarts) largely diluted with common air. (This oxygene air must have been purer than that which she had breathed before, as it had stood by a long time in the air-holder, in which some water was purposely left to absorb the fixed air, from which I have reason to think that it was not thoroughly freed during its passage through the refrigeratory.) At this and the subsequent repetitions of the application, the strokes of the artery in the wrist were stronger and fuller than before the inspiration. On account of pain in the side, head-ach, and uneasiness at the stomach, of which she complained the next day, the application was suspended, and was not again repeated till the 22d of January, when she breathed only a quart of oxygene. In the interval no other medicine was given but Rochelle salts, to keep the belly open, and take off the fullness and quickness of the pulse. — 23d. A quart more. — 24th. The same quantity. Mr. Taylor, the apothecary to the hospital, superintended the last mentioned applications, as I was prevented from being present myself. When I saw the patient the day after the last inhalation, I found her pulse, appetite, spirits, and countenance much improved. An accident having befallen the apparatus, and the stock in the air-holder being exhausted, we were obliged to discontinue the application. The girl was discharged on the 31st of January, much better as to her general health, and particularly with more colour and more animation in her countenance; but in respect to the menstrual evacuation, the same as before. When she left the hospital, she had directions to come again after five or six

weeks; when, if the suppression of the menses should still continue, I intend to repeat the pneumatic application. — I have likewise given oxygene air to another patient afflicted with epilepsy joined with amenorrhæa; but as I have not, in this case, repeated the application sufficiently, I do not yet think myself warranted to speak of its effects.

I am, dear Sir, with great regard, your's,

RICHARD PEARSON.

Birmingham, Feb. 2, 1795.

P.S. From what I have seen of the effects of oxygene, I think it should at first be applied in more diluted doses than those in which you seem to have given it. In my little pamphlet I have said (p. 4) that "at the first time of using it, it should be mixed with 8 or 10 times its bulk of atmospheric;" but I think it will in most cases be prudent to dilute it with as much as 12 or 15 times its quantity of common air.

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Extract of a Letter from DR. THORNTON.

A gentleman, Mr. T——d, was recommended to me by Mr. Baker; he had been afflicted with asthma for the last 13 years. Having loss of appetite, great muscular weakness, cold extremities, and a languid pulse, I directed him to inhale a super-oxygenated air. After six weeks trial of the efficacy of this new means, accompanied with medicines, his asthma was not diminished, which surprised me, as I had in this way relieved and cured several asthmas this winter and the preceding, but on the contrary it seemed somewhat increased. This gentleman was now seized with a violent cold; fearing the recent oxygenation might increase the inflammatory symptoms, I directed him to inhale

inhale hydrogen gas, diluted with atmospheric air. The heat and soreness at his breast were immediately taken off. He repeated this, and he is himself fully persuaded, from the knowledge he has of his own constitution and the lasting effects of a cold with him, that the hydrogen gas prevented, or rather cured this catarrhal attack; upon a more particular inquiry, I found he was in the habit of relieving his asthmatic fits by going to the play, which succeeded if he went into the upper gallery, but not if he sat in the pit, and that a sharp easterly wind was sure to bring on a paroxysm, if he walked in the face of it; and that he was never so well as in crowded rooms, and in foggy damp air.

When Mr. T——d inhaled an oxygenated atmosphere alone, he was accustomed, though the oxygene was very considerably diluted, to awake early with difficulty of breathing, a long fit of coughing, the breath hot, and the tongue parched. When he began to inhale the hydrogen air, he fell asleep sooner than before, slept composedly, and had none of the above symptoms. Since the catarrh was cut short by the hydrogen, I have ventured to give him a little oxygene by day, with hydrogen at night. He is going on well; falls asleep soon after taking the hydrogen, and is quite exempt from the above-mentioned disagreeable complaints.

I cannot help adding, that I had lately an opportunity of observing a fact, which seems to favour your idea of muscular motion, as dependent upon oxygene. An asthmatic patient after going up stairs was always obliged to remain quiet in her chair near ten minutes, before she could enter into conversation. The progress of her recovery not being so speedy as she could wish, she fancied

fancied the vital air in a state of dilution did her no service.—After inhaling the quantity I judged prudent, I have begged her to go down stairs, and walk up as quick as usual, or rather more so, which she obligingly did, and was then able to converse the moment she entered the room.

Ever your's,

R. I. THORNTON.



The Rev. Mr. F——, at Bristol Hotwells, much troubled with dyspnœa, and mucous expectoration, used to assure me, that after inhaling diluted oxygene air, he could walk up the steep hill to Clifton, with much greater ease than at other times. He made the experiment innumerable times. This air, however, rendered him no permanent benefit; his disorder depending upon mal-confirmation.

We may admit these facts, as they seem clearly ascertained, and supported by many analogies. But would not æther or other drugs have done the same? And was the effect procured by the *specific* power of oxygene? A good reasoner ought not to admit such power till there shall have been made a number of comparative experiments, of which no man has perhaps conceived the idea. It is, for instance, possible, for any thing we know to the contrary, that certain substances introduced into the stomach shall prevent an animal from drowning so soon as its unprepared fellow, without communicating oxygene to the system, and thus, to a certain degree, rendering respiration superfluous. In this case it would be doubtful whether oxygene acts

on

on the same principle as the bodies, producing an effect so far equivalent, or on a principle peculiar to itself. When we are acquainted with the result of these more extensive researches, we shall not be in so much danger as at present of being seduced by narrow views into wrong conclusions.

In November, 1794. Mr. James Tobin, of Bristol, informed me he had heard of instances of amaurosis, in which benefit had been derived from inhaling oxygene air. From my own experience I could not give him any encouragement, except as to the probable safety of the trial; but as he had lost the sight of one eye entirely by this disease, and had that of the other exceedingly impaired, he determined upon the experiment. He ventured upon the quantities specified in the following note, with which he favoured me from memorandums made at the time. Not the smallest difference for the better or the worse was experienced at the time or since as to his vision.

“ Mr. James Tobin for fourteen days in December, 1794, took of atmospheric mixed with equal parts of oxygene air, from five to six of Mr. Watt’s smaller cylinders daily; having discontinued it for a fortnight, he began again taking of the same proportions five cylinders for nineteen days: — four minutes are more than sufficient for the breathing of one cylinder i. e. $\frac{1}{3}$ of a cubic foot of this air. Mr. J. T. has occasionally breathed the pure oxygene without any inconvenience, nor could he absolutely ascertain any effect from the mixed air, though he sometimes thought he derived from it the power of resisting cold. The proportion of oxygene is so
great

great in this mixture as to add brilliancy to the flame of a candle after it has passed through the lungs."

—*March 23, 1795.*

I have received general information concerning several other patients to whom oxygene has been administered. Complete reports will, I hope, be published in due time. In some of those patients scrophulous tumours have disappeared during this treatment. In one a combination, which I had recommended several months ago in such cases of cancer as should resist the external application of carbonic acid or other unrespirable airs, has been employed with great advantage, and will probably effect a complete cure. Carbonic acid air having been applied for three months to a cancerous ulcer of the breast without mending its state, it was conceived that the inhalation of oxygene air, together with the continuance of the external application of the c. acid, might produce an effect to which the latter alone was not equal. In less than a fortnight after this alteration in the treatment, good pus was discharged, healthy granulations appeared, and the ulcer was much diminished. There has since been a gradual progress toward recovery, and the cancer, I am well informed, "is all but healed."

XVIII. — *Cases in which different unrespirable airs were administered.*

Letter from DR. FERRIAR.

Manchester, Jan. 23, 1795.

SIR,

It would afford me sincere pleasure if I could furnish you with any decisive proofs of the efficacy of Pneumatic Medicines ; but my trials of them have not yet been numerous, and my patients have not been so regular and persevering as I could have wished. I began to use hydrogene about two months ago, with an elderly man, who had every symptom of confirmed phthisis, and whose complaints had been ushered in by hæmoptoe. His pulse was 120, and very quick ; on that day when he first breathed the mixture, there was $\frac{1}{4}$ of hydrogene. He remarked that he did not cough during the rest of that day ; and the next morning his pulse was only from 60 to 70. By administering a dose of the air morning and evening, and increasing the proportion of hydrogene to $\frac{1}{3}$, he obtained several easy nights, tho' the weather was frosty, and a thick fog prevailed for several days. These favourable appearances are now over ; for the air no longer gives him relief, owing, I apprehend, to the period of the disease. When the hydrogene lost its efficacy, I gave him the dydro-carbonate, and afterwards oxygene, without benefit.

The next case in which I used hydrogene was that of a lady who had been harassed with a spasmodic asthma upwards of 11 years. During the last two years and half, she had seldom been free from a paroxysm above four days together. After breathing the
mixture

mixture with a third of hydrogen, she complained of a sensation of fulness in the lungs, and of severe coldness. I prevailed upon her to use the medicine twice a-day for some time ; and she has certainly been more free from the asthma than she had been at any time for the last three years. In the course of two months, she has had only two paroxysms, and they have been shorter than usual. I have attempted to relieve her during the paroxysm, by giving oxygen, but without effect.

I made a patient at the Infirmary inspire a mixture, with the common proportion of oxygen in my presence, a few days ago. The man has had a severe asthma during several years, which only quits him in the middle of summer. He had been once free from his complaint for a considerable time, by taking bark and opium under my direction. After inspiring the air, he said he felt himself perfectly easy, and that if he could continue so, he should think himself well.

He has neglected, however, to return as I desired, for another dose,

I have found no inconvenience result from the exhibition of the airs ; on the contrary, the consumptive patient whom I first mentioned, thought his appetite and spirits improved by the use of the hydrogen.

I hope, in a short time, to acquire more facts on this subject ; in the mean time I shall be very happy if these slight observations can be of any use to you.

I am, Sir, &c.

J. FERRIAR.

To Dr. Beddoes.

Letter

Letter from DR. CARMICHAEL.

DEAR SIR,

The Hydro-carbonate, so far as my observation goes, has never failed to afford very sensual relief in Phthisis Pulmonalis. Consumption occurs very frequently in this place; but it rarely happens that a physician is applied to early in the disorder, when much advantage may be expected to be derived from the use of modified air. The persons affected with Phthisis, whose cases are detailed below, were reduced to the brink of the grave, and cannot therefore be considered as favorable subjects. I have however the satisfaction to inform you, that the hydro-carbonate has hitherto relieved one of them, and that the sufferings of the two others were uniformly and greatly alleviated. No medicines having been used at the same time, the effects produced are to be attributed entirely to the virtues of the facitious air.

J. A. applied for my advice Dec. 1, 1794; has very frequent cough, attended with copious expectoration, pain of his side, dyspnœa on the slightest bodily exertion, colliquative sweats and diarrhœa, very restless nights, strength much impaired, p. 115. These complaints originated about five months since without any evident cause, and notwithstanding many remedies used have continued to increase. I prepared a mixture of hydrocarbonate and common air, in the proportion of one quart to nineteen, which he inhaled at intervals as directed below in J. T.'s case (p. 87.)—2. The vertigo produced was considerable, and from which he did not compleatly recover for upwards of an hour. Has had a very comfortable night, cough relieved, and he expectorates

torates with more ease, p. 108; breathing less difficult. —6. Pain of side and dyspnœa gone, cough not so frequent, fœtor of the matter expectorated not so offensive, diarrhœa less frequent; perspiration much less profuse, p. 104; sleep has been uniformly good since he began the use of the modified air. Vertigo produced still considerable, and after having once gone completely off, continues to return at intervals during the day.—13. All his symptoms better except in point of strength, which seems gradually to decay. His mother requested me to inform her whether or not it was my opinion that her son could recover; I replied that I had little expectation of so favourable an event, but that his life might be prolonged and rendered more comfortable by the use of the modified air. From this time, however, for five days, I saw no more of him.—18. He returned to-day, and earnestly entreated me to suffer him to inhale the modified air as formerly. All the symptoms were greatly aggravated, the fœtor of his breath was intolerable, and his diarrhœa had returned with increased violence, p. 120; he breathed the same mixture as at first prescribed for him.—19. Hydro-carbonate occasioned considerable vertigo, has passed the night comfortably, and seems much refreshed by his sleep, cough less urgent, p. 108.—24. Cough less frequent, dyspnœa less urgent, fœtor of his breath less offensive, sleeps well, body regular, p. 104. Notwithstanding the relief of his symptoms, his strength is evidently declining.—30. Continues the same.—Jan. 12, 1795. Since the last report, owing to the severity of the weather, he was prevented from attending. I am this day informed that his diarrhœa returned with great violence and carried him off on the 10th instant.

S. C. æt. 32, was about nine months since, in consequence of exposure to cold and wet, seized with a cough and pain at his breast, which symptoms were soon after attended with considerable expectoration. I first saw him towards the end of July. His cough was then severe and attended with copious expectoration of a whitish ropy fluid, he complained of flying pains of his thorax, dyspnœa on any slight exercise, restless nights, and strength much impaired, p. 100. He was at that time engaged in business, but as his strength was but ill-adapted to the attendance required, and his mind seemed little at ease, I recommended to him to leave such scenes for the present, and if he conveniently could, to retire for a few months into the country. With this advice he readily complied, and I saw no more of him until the middle of October, His mended appearance bespoke the benefit he had derived, he had had no pain in his breast for some weeks, and could use considerable exercise without any return of dyspnœa, his appetite was much better, and he in general slept pretty well, his cough and expectoration continued in a less degree. But this glimpse of hope was only of short continuance, he gradually lost the ground he had acquired, to his former symptoms new ones were added, so that at the end of November, when I again saw him, it was but too evident that he could not much longer struggle with so formidable a disease. — Dec. 4. Cough very severe, copious expectoration of a ropy whitish phlegm, dyspnœa urgent on the slightest exertion, nights very restless notwithstanding he is in the habit of taking a grain and half of extract of opium at bed time, profuse perspirations, p. 110, body regular, appetite and strength much impaired. I directed him to inhale a mixture containing

containing one quart of hydro-carbonate and nineteen of common-air, once a-day, and desired him to omit the opiate at bed-time.—5. Considerable giddiness produced by the hydro-carbonate, and he complains that to-day he feels himself more languid than usual. Slept better than he has been accustomed to do for some weeks past.—10. Cough much abated, expectorates with more ease, pain of his side gone, dyspnœa on motion less urgent, continues to enjoy very comfortable nights, perspirations much less profuse, p. 90. — 15. Continues to find relief from the modified air. — 20. For the two last days his cough has been rather worse, and his nights restless, p. 100, body costive. I directed him to take a little rhubarb occasionally. — 25. Body regular, cough relieved, and he has slept better; for some time past no perspirations, p. 90. — 30. He is evidently more emaciated, his voice has become more feeble, and his step is less firm. Cough variable, expectoration rather more copious.—Jan. 4. 1795. Considerably affected by the severity of the weather, cough increased and attended with a sense of tightness in his breast, and at times with pain under his sternum.—27. I heard nothing of him for some days subsequent to the last report. Finding himself getting worse, he was advised to apply elsewhere, but medicine was of no avail, and I am informed that he sunk under his complaints two days since. — Had it been possible for me to have supplied this patient, and him whose case is before detailed, with modified air at their own houses, during the unusually severe weather, might they have not recovered?

J. T. æt. 40, has for two years past been affected during the winter and spring months with cough and
expectoration,

expectoration, and at times with pains in his breast, accompanied with slight dyspnœa. These symptoms in general left him during the summer months, and never at any time arose to such a degree as to prevent him from following his usual occupation. In the beginning of October last, he was seized with pain of his side, cough, dyspnœa, and after some time with copious expectoration. He applied for my advice in the beginning of November. At that time he had an almost incessant cough, attended with copious expectoration, he complained of a sense of tightness across his thorax, and much dyspnœa on the slightest exertion, his pulse was in general from 110 to 120, his nights were restless and attended with profuse perspirations, his body was irregular, his appetite much impaired, his frame much emaciated. I ordered for him at different times emetics, squills, ammoniacum, blisters, &c. but from none of them did he derive more than a very temporary relief. —Nov. 27. He began the use of the hydro-carbonate. I directed him at first to inhale a mixture containing a quart and a half of this species of factitious air, and nineteen of atmospheric air. This quantity he used in about twenty minutes, breathing it for twenty seconds together, and then resting for one, two, or three minutes, according to the degree of vertigo produced.—28. The vertigo produced by yesterday's inhalation was very severe, and returned at intervals during the evening. He has passed a much better night than usual, and says that the dyspnœa and sense of stricture on the thorax are much relieved. The quantity of hydro-carbonate diminished to one quart, diluted as above.—30. Cough much relieved, sense of stricture gone, dyspnœa less troublesome on motion, has had better nights, and his perspirations are less profuse, p. 106, appetite rather

G

better,

better.—Dec. 7. Cough evidently better, expectoration considerably diminished, p. 95, body for some days past regular, breathing so much improved that he can with ease walk up stairs to his chamber and undress himself, without return of dyspnœa, which he could not before accomplish without the greatest difficulty, sleeps better than he has done for months past, perspirations entirely left him, appetite mended.—15. Continues to recover in every respect, has at times some return of tightness of his breast, but which is uniformly relieved or completely carried off by the hydro-carbonate. His countenance is evidently altered for the better, and he is of opinion that his strength returns. Notwithstanding that the modified air still continues to produce considerable vertigo, I increased the quantity to two quarts, diluted as before.—27. Cough very much relieved, expectorated matter reduced to one-third of its former quantity, p. from 84 to 90. He has evidently acquired flesh, and he is of opinion that his strength continues to improve.—Jan. 6, 1795. Cough rather more frequent, and attended with some degree of dyspnœa. On account of the severity of the weather, which evidently affects him, I ordered him not to stir from home. At this time he began to breathe the modified air of the strength directed above, twice a-day.—16. Cough relieved, quantity of expectorated matter much the same as reported on the 27th ult. in other respects the same.—Feb. 1. On account of the unusual severity of the weather, no advance has been made since last report. Cough more variable, and at times attended with some degree of dyspnœa, expectorated matter rather increased, he does not however emaciate.—12. Cough much abated, quantity of expectoration reduced to one fifth of its former quantity,

his

his strength is so much recruited that it is with difficulty I can restrain him from returning to his occupation. In every respect he is much better.—March 1. Continues to gain strength, cough less frequent, and expectation still diminishing in quantity, appetite good, sleeps well. As I could not prevail with him to remain longer at home, I advised him, before he returned to his usual occupation, to walk out a little daily.

It is much to be regretted that this patient would not be persuaded, or could not afford to devote himself entirely to the care of his health. His return, however, to his usual occupation, and consequent exposure to the severities of such a season, form an æra in his case; and Dr. Carmichael has promised me a continuation of his history. I shall not fail to communicate the event to the public in the course of the present year: cases now in progress, besides those mentioned in this pamphlet, will enable me in a few months to add a small Appendix.—This patient recovered perfectly, as may be seen in Dr. Carmichael's curious account, published in the promised appendix, viz. *Considerations*, Part III. [T. B.]

In prescribing the use of this species of factitious air, supposing my patient to be 19 years of age or upwards, I begin by directing 1 quart of hydro-carbonate to be mixed with 19 of atmospheric air. In this proportion it may be inhaled for fifteen or twenty seconds together, without producing much uneasiness of the head or vertigo; it is then prudent to desist until such time as any feeling occasioned by it goes off, which will in general require from one to five minutes. Vertigo universally accompanies the use of the hydro-carbonate, even in much smaller doses than those which

I have above directed. At first the patient is sensible of a tightness across his forehead, and a sense as of something creeping round his ears and back part of his head. These symptoms gradually increase, until they are lost in vertigo, or if imprudently too much has been given in a slight degree of apoplexy. I have made use of spirits, water, and volatile effluvia, to restore patients overcome by this species of modified air, but nothing seems to answer the purpose so well as exposing them freely to a current of the atmosphere. I in general make use of incipient vertigo as a test how much of the mixture patients may breathe at a time, and unless it produces more or less of this effect, I do not find that the advantages derived are so conspicuous. The proportion of the hydro-carbonate may be increased as the system becomes habituated to its operation. J. T. at this time takes a gallon of hydro-carbonate diluted with four gallons of atmospheric air, twice a-day, and without producing much disturbance in the system. The other two patients never inhaled the modified air stronger than in the proportion of two to eighteen, nor oftener than once a day.

In preparing the hydro-carbonate, I find it to be of the utmost consequence to suffer water to pass from the water-pipe in the most gradual manner. By doing so the air comes over much slower, but its purity compensates for a little loss of time. If much water is used a considerable quantity of hepatic and aerial acid airs are generated. The latter is of little consequence, as it may be absorbed by quick-lime put into the refrigeratory, but the former being inseparable from the hydro-carbonate, increases dyspnoea when present, and I have suspected it sometimes of occasioning pains in the breast.

The

The hydrocarbonate looses much of his activity by keeping, it does not produce vertigo in the same degree, and I have not observed the same beneficial effects result from its use. On recurring to fresh prepared air, it is necessary to begin again with a very small dose.

I am, dear Sir, &c. &c.

JOHN CARMICHAEL.

Birmingham, Feb. 12, 1795.

The collection of letters from Dr. Withering and others being out of print, and not likely to be ever republished, I shall extract the following important observation. Whatever opinion be formed concerning the nature of the case, the patient clearly appears to owe her life to the pneumatic treatment.

Extract from a letter from Dr. EWART, dated November 14th, 1793.

The other case in which I employed the inhalation of mephitic air, was that of a lady (Mrs. P) aged about 22 years; who nearly two years and a half ago, was seized in Russia with symptoms of a violent pleurisy, after incautiously eating iced cream when over-heated. Notwithstanding blood-lettings and other evacuations, the inflammatory symptoms seem to have run into a rapid suppuration; for eight or ten days after the first attack, and after a severe fit of coughing, almost immediate relief followed the sudden expectoration of a large quantity of what was deemed pure pus, slightly intermixed with blood. But though the pain and dyspnoea now abated, still a frequent cough and a very

copious expectoration of a similar matter to that discharged at first, remained; and soon her fever assumed a hectic form. She was in this situation recommended to come to England, but experienced no benefit either from the sea-voyage or from the use of the Bristol hot waters, which she drank during some months. So much of her case I give from her own report. From Bristol she came to Bath in the beginning of last January, when I first saw her, eighteen months after the commencement of her illness. The state of circumstances then was, very considerable and *progressive* emaciation, an almost constant hectic flush on the countenance, the pulse always quick, with regular and strong exacerbations of fever towards evening, which again abated before morning, and were succeeded by profuse sweats; the cough was very frequent, and the expectoration so profuse as completely to wet many handkerchiefs daily. She began now to inspire mephitic air, pretty nearly in the same manner as Colonel Cathart had formerly done. She not only repeated, however, the inhalations from the machine oftener and continued them longer each time than was done in his case, but even while she was not inspiring through the tube, the machine generally remained on a table near her, emitting the fixed air which was continually extricated from the mixture of calcareous earth and vitriolic acid it contained, so that I seldom entered her apartment without perceiving mephitic fumes in a greater or less degree. The apartment being close and of no great extent, I sometimes thought it prudent to have a window opened for the purpose of clearing it of these fumes. Particular circumstances rendered it necessary that I should inform the lady's relations without reserve, what chance I saw of her recovery; and

and in the beginning of my attendance I did not hesitate to express my despair of doing her any good, or of ever seeing her better. Such however was soon the abatement of all her symptoms under the above treatment; so entirely for some weeks did the hectic fever disappear; and so evidently did she gain during the same period both flesh and strength, that not only her relations acquired new and sanguine hopes of her recovery, but I began seriously to flatter myself with a disappointment of my predictions, although I durst not venture to avow it. The first check given to this amendment, which proceeded for four or five weeks, was occasioned by an over exertion of her lately recovered strength, during a fatiguing walk, the latter part of which was up a pretty steep ascent. A return of pain in the breast and dyspnoea, a tinge of blood in the expectoration, together with an accelerated pulse, made me have recourse to blood-letting, blisters applied to the chest, &c. which greatly relieved these symptoms, but at the same time reduced the general strength. The inhalation of mephitic air was interrupted during the period of this inflammatory attack, from an uncertainty how it might act, rather than from any observation of its disagreeing; but it was repeated as before, after the symptoms of inflammation had abated, and again seemed to produce the same beneficial effects. A second relapse however occurred some weeks afterwards from a slight indiscretion, the throwing off part of her accustomed garments. This was removed much in the same way as the former one, and the mephitic air was again resorted to with similar success. After each of these inflammatory attacks, and after one or two others which happened subsequently, there remained for some time a considerable
increase

increase of cough and expectoration, and a permanent hectic, which however gradually abated under the use of the mephitic air. But these repeated relapses from slight causes, notwithstanding the constitution rallied astonishingly afterwards, and soon seemed to regain all it had lost, renewed my fears that the disease would soon run the usual and rapid course of confirmed phthisis. The patient left Bath in the month of May last, to take advantage of the summer season for trying another voyage by sea, still bent on continuing the inhalation of mephitic air. I despaired of hearing much longer any favourable accounts of her; but have been repeatedly and agreeably disappointed, in learning that her health has since gained instead of losing strength. By a letter received within these few days from Petersburg, where she has passed the summer, it is reported to me "that she is wonderfully recovered by the Balsam of Mecca, which she got from the Turkish Ambassador." Whether she has all along continued the mephitic air, I cannot undertake to assert, but I believe in the affirmative, from her intentions at the time of leaving this country. To whatever cause her preservation is owing, it is the first case of so fully formed, and so far advanced a phthisis that I have met with, in which the progress to dissolution has been so long restrained, or so successfully repelled.

I remain, dear Sir, &c.

JOHN EWART.

—Accounts from Petersburg of a late date state the amendment of this lady to be more considerable than I ventured in my last letter to represent it. It was her intention to pass the winter in the South of Russia, but

but she now thinks herself so well as to be able to remain with impunity at Petersburg. The expressions of her father in a letter to her sister are, "She has recovered progressively ever since she returned here, regains flesh and strength, is free from fever, and suffers very little from her cough, but continues to spit immoderately, though with ease." No mention is made in this letter whether she persists in respiring fixable air.

Your's, &c.

Bath, Dec. 15, 1793.

J. E.

Bath, March 25, 1795.

MY DEAR SIR,

In the beginning of the winter Mrs. P. was found to be pregnant, and has been delivered of a healthy child. Lady H. from whom I had an account within the last fortnight, mentions no particular symptoms, but only says her sister is vastly well. She has not breathed any factitious air since her return to Russia; so that all which can be inferred from her case, applicable to your subject, is the evident amelioration of symptoms which first began to take place here under the use of the carbonic acid air. I have since administered the same air in a considerable number of cases of phthisis. I can say with confidence that in most of them it relieved the cough; but in none of them, where the disease was fully formed, could it be said to produce beneficial effects in any degree equal to those observed in Mrs. P.'s case. In two cases of apparently incipient phthisis, the symptoms entirely disappeared

disappeared under its use ; but the difficulty of distinguishing certain states of simple catarrh, from the first stage of genuine phthisis, leaves it with me still a matter of doubt, whether these two cases were strictly of the latter description or not.

One remark on Mrs. P's, case is likewise obvious, that although her disease had proceeded to a very formidable length, with every symptom which characterizes the last stage of phthisis, yet as it originated in a pleurisy, brought on by a sudden cause, and without evidence of any particular predisposition to phthisis, it may have been a simple imposthume in the lungs, unattended by tubercules.

Yours, &c. &c.

J. EWART.



Dr. Pearson, in a letter from Birmingham, dated January 15, 1796, informs me that he has continued to direct the æther-vapour with much advantage.—“ My facts,” says he, “ in favour of æther-vapour, in phthical cases, are multiplying so fast, that in about another half year, or by next winter at farthest, I expect to have a number of cases worth communicating to the medical world.” He has varied his method, by making additions to the æther, as he will no doubt relate at length, if happily his expectation should be fulfilled.

Concerning Dr. Thornton's comments, he proceeds, on my observations on yeast *, I have to remark that I approve of the freedom with which he writes. But
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* See Considerations, Part III, p. 101.

I am by no means convinced that the violent operation which I have seen from its use, was merely the effect of flatulency. In every draught of bottled beer or porter, we probably take as much fixed air as is contained in the assigned doses of yeast; and, yet, windy as they are, these liquors do not (unless taken immoderately) excite vomiting or purging. Perhaps Dr. Thornton will account for this from the alcohol or brandy that is in them; but he cannot say the same of pure water saturated with fixed air, which, in proper doses, neither disorders the stomach nor bowels. The arguments drawn from the effects of yeast applied externally, and the analogical reference to the carrot-poultice, have very little weight: for, although I readily ascribe with him their beneficial effects, when used in that manner, to the fixed air which they give out; yet there is a wide difference between the state of the skin and the state of the stomach—between the former when affected with foul and sphacelating ulcers, and latter as it is in typhus, without such ulceration, whatever else may be its morbid condition. The fermenting pulp of the carrot would be but a clumsy vehicle for conveying fixed air to the stomach in the goal or other fever; it would oppress by its bulk and indigestibility. In like manner, yeast is unfit, as an internal medicine, in many cases, where fixed air, applied through a lighter and simpler medium, would be serviceable, not only on account of the bitter oil of the hop, with which it is impregnated, but also on account of the insolubility or indigestibility of the feculent or glutinous matter, which constitutes the chief part of its bulk. This part is barely miscible with, but not soluble in water, whether cold or hot. It is
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in like manner insoluble in ardent spirit. It serves to give form and body to the remedy when used externally : but it is, oppressive, irritating, and in every way offending, when applied internally. By means of a little gin, or any other spirituous liquor, the stomach may, in some cases, be made to bear it. Many other offending substances are, by the same means, rendered tolerable to it ; but by such an addition we only convert the yeast and water (with which it is diluted) into a bad kind of fermenting liquor, the end of which will be much better answered by a draught of bottled beer, porter, perry, &c. On the whole, I have no doubt that yeast will stand its ground as an external application ; but I fear it will daily lose its reputation as a remedy internally. I cannot account for the benefit which Dr. Thornton has uniformly experienced from the exhibition of it in cases of fever, otherwise than by supposing he has used the frothy part only, separated from the denser liquid part, which subsides by standing. If so, the Doctor should make this circumstance known.

R. P.

Dr. Pearson has lately given from Dr. Bergius an interesting experiment on the celebrated remedy of *cow's-breath* in consumption. A Swedish lady, who had been subject to spitting of blood, was affected with cough, great expectoration and night sweats. She was exceedingly emaciated ; difficulty of breathing rendered it necessary to bolster her up : she had constant diarrhœa and swelling of the feet. In this last stage of consumption, when the physicians had relinquished all hope, a large hall was provided with stalls for four cows, and with a stage on a level with the heads of the cattle, upon which the patient's bed and chairs were placed.

placed. She took possession of this station in September : in a month some amendment had taken place ; and by Christmas all her symptoms were surprisingly mitigated. Her fever was abated so much that her pulse had become natural. In summer she was able to quit her habitation ; she gained flesh ; the catamenia returned ; and she had to complain only of a slight cough and quickness of breathing when she walked. The ensuing winter she would not submit to pass her days in the hall with her cows. In the spring she caught cold, and suffered much from inflammation of the lungs. The phthysical symptoms returned in autumn ; but she now refused even to pass her nights near the cows ; she died at the end of winter. The progress of this case during the first winter differs so totally from the constant course of consumption, especially when the patient is far reduced, that we can scarce hesitate to ascribe efficacy to the plan pursued, Dr. Pearson thinks the patient's escape from imminent death may be imputed to the lowered atmosphere and the carbonic acid produced by the respiration of the cattle. I do not suppose much will be attributed to the balsam of their breath.

If nothing was owing to the fumes of volatile alkali, with which the atmosphere of the hall must have been loaded, we may at least conclude that no injury is likely to arise from the spirit of hartshorn in the apparatus represented in Pl. IV.

In the pamphlet whence this observation is taken, the beneficial effect of the atmosphere of the West India sugar-houses in consumptive cases is noticed. Carbonic acid abounds in these places. I have received

ved intelligence of the complete recovery of a consumptive patient who constantly breathed the air of an American tar-house, which I suppose may be of much the same quality as that of the sugar-houses.

The following fact I shall not attempt to force into the service of my speculations. I leave it, as the relater has judiciously done, to be determined by others whether the kind of atmosphere the patient breathed for so long a continuance had any share in the ultimate effect. That much was owing to another obvious cause I do not pretend to doubt, and it seems worth preserving as an instance of the good effect of long-continued nausea and repeated vomiting. Moreover, the narrative may suggest the trial of complicated powers where the single fail. Turn and twist our means how we can, we may esteem ourselves happy when we succeed at last.



Letter from Mr. CHISHOLM to Dr. EWART.

Bath, February 16, 1795.

DEAR DOCTOR,

The case which you desired I would send you an account of, was as follows: — A negro man, a servant of mine, aged 28 years, of a strong muscular make, a bricklayer, in December 1787, after spending some days in hard drinking, and dancing in the open air, was seized with a violent pleurisy, attended with strong fever, and all the usual symptoms; he was several times let blood and blistered; he also took a good many doses of James's fever powder; by which the symptoms of general, as well as topical inflammation, were much abated, and it was expected he would soon recover,

cover. He however continued to complain, and in a few days it became evident, that matter was forming in the right lobe of the lungs ; some weeks thereafter he suddenly brought up a considerable quantity of ill-digested matter, mixed with much blood. I immediately on this had him removed to my own house, where, during two months, both food and medicine were administered to him with the greatest attention. During all that time, however, he continued to be afflicted with a most incessant cough, expectorating considerable quantities of very ill digested matter, always much tinged with blood, a great degree of hectic fever, and at last profuse colliquative sweats, with great loss of strength. I was perfectly satisfied he must soon die, of which he himself was so much convinced, that he requested I would send him home, as his wish was to die in his own house. I then proposed he should try the effects of a short voyage at sea, to which he consented ; he was accordingly sent in a chaise to our nearest shipping place, distant about 20 miles, with directions to have him put on board of one of the small vessels employed in the coasting trade of Jamaica. He was accordingly put on board of a single decked vessel, about sixty tons burden, the only one at that time about to sail from our port, and I heard no more of him for six weeks ; at the end of that time I received a letter from the person who had the care of the wharf, informing me he was landed there in a dying condition, and desiring I would send a chaise for him ; which I accordingly did, with directions to make very short stages. At the end of four days he was brought to me, and to my astonishment appeared in good spirits, and seemed convinced he should recover. On examining I found his pulse good, the hectic fever having entirely left him,

him, and although he had still a short teasing cough at times, there was nothing expectorated. From that time he took no medicine whatever, but was plentifully supplied with nourishment, consisting principally of panada, rice, and milk; in three months was perfectly restored to health and strength, and went to work as usual ; he is still alive, and in good health, and has never had any return of his pulmonary complaints.

The account he gave of his voyage was this : — Immediately on the vessel's sailing, he was seized with a violent vomiting, occasioned by sea-sickness, which continued with short intervals, during the whole time he was on board ; that being unable either to stand or sit up much, he spent the greatest part of the time, under the deck of the vessel, lying on the top of the cargo, where the air is necessarily very bad, as these vessels are generally loaded either with hogheads of raw sugar and puncheons of rum, or barrels of salted beef and pork, and I believe are very seldom ventilated. The only nourishment he took was ship biscuit, pounded and mixed with water ; he was, in consequence, when first landed, reduced to so great a state of debility and langour, he imagined he was dying, but after a night's rest, and having taken a good deal of wholesome nourishment, his spirits were restored, and he found his original complaints had in a great measure left him.

My own opinion at the time was, that his cure had been effected by the frequent vomiting, not having ever heard any thing of the beneficial effects of stowed air. What share that might have in the cure, you are a better

a better judge ; the case was simply as above stated, on the truth of which you may rely, every part having passed under my own daily observation, excepting during the time he was on board the vessel ; and of the truth of his account of that, I have not the smallest reason to doubt.

I am, your's, &c. &c.

To Dr. Ewart.

JAMES CHISOLM.

Extract of a letter from Dr. CARMICHAEL.

Birmingham, March, 1795.

I. B. æt. 45, was attacked about four months since with difficulty of breathing, attended at times with pain under the sternum, and commonly with a sense of tightness of the thorax, frequent cough, with copious expectoration of a tough whitish fluid, p. 96, body regular, appetite variable. He has seldom passed four and twenty hours without a material aggravation of all his symptoms. Was first attacked with this disorder six years ago, and has regularly suffered very severely from it every winter since that period ; it has always left him about the beginning of May, and he has kept free from complaint during the summer and autumn months. He has tried many remedies, but never with more than very transitory relief.

February 14, 1795, I directed him to inhale daily a mixture of hydrocarbonate and atmospheric air, in the proportion of 1 to 19.—15. No sensible effects from the use of the hydrocarbonate ; the strength of the mixture was therefore increased in the proportion of 2 to 18.—16. No vertigo, nor any other sensible effect pro-

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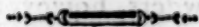
duced

duced by the use of the modified air. The proportion still farther increased to 4 to 18. — 17. Considerable vertigo produced by yesterday's dose, which returned at intervals, attended by head-ache during the day. Breathing much relieved, even during the act of inhaling the modified air, and has since continued tolerably easy. Slept better last night than he has been accustomed to do for some months. — 22. Hydrocarbonate continues to produce considerable giddiness, breathing, except some short intervals of slight return, continues much easier. Cough less frequent, expectoration much diminished. Continues to enjoy comfortable sleep. — 27th. Had a considerable return of difficulty of breathing on the afternoon of the 25th, which, however, abated so much before his usual bedtime, as not to prevent him from passing the night comfortably. Cough infrequent, and rarely attended with expectoration. Has for some time past had no pain under his sternum, and rarely any sense of tightness of his thorax. — March 4. He is in every respect so much better, that he intends to return to his usual occupation (making moulds in a cast-iron foundry) on the 9th instant. Modified air continues to produce vertigo. — March 9. He continued without any return of his complaint, and returned to his employment as he intended; but after working for a few hours only, he was obliged to desist, by a return of the sense of tightness on his thorax, and considerable difficulty of breathing. — Breathing increased in difficulty towards evening, and still continues, attended by frequent dry cough. — 13. Continues to breathe with considerable difficulty, p. 100; sleepless nights; cough more frequent; but now attended with considerable expectoration. — 17th. Difficulty of breathing continued until yesterday;

yesterday; has passed a better night than usual; and this morning finds himself much better. —20. Breathing continues easier; cough much less frequent; and quantity of expectoration diminished. Has slept for some nights past comfortably, p. 86. Modified air continues to produce considerable vertigo. —29. Continues uniformly to recover; his cough is very trifling, and he expectorates better; his strength is so much improved, that he can use considerable exercise without inconvenience. Sleeps uniformly well.—He returns to work to-morrow, but for the present is to work within doors. He is of opinion that he is in every respect equal to the undertaking.

I remain, Dear Sir, Your's, &c. &c.

J. CARMICHAEL.



XIX. Mr. WATT's *hints on the operation of different airs.*

Heathfield, June 17, 1794.

DEAR SIR,

Having never made the art of medicine my particular study, I should not have troubled you with my crude ideas upon the use of pneumatic medicines, if your approbation of what I mentioned to you, joined to my earnest desire to aid your endeavors, with the hope that possibly some idea might be started, which may save other parents from the sorrow that has unfortunately fallen to my lot, had not urged me to step over the bounds of my profession.

It appears to me, that if it be allowed that poisons can be carried into the system of the lungs, remedies

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may be thrown in by the same channel. Remedies for some fatal or dangerous disorders may, possibly at least, be found in the class of airs, which admit of many *known* modifications, and doubtless many more still to be discovered : — which of these may prove beneficial in consumption, and other analagous disorders of the lungs, remains to be ascertained by experiment. You have shewn that oxygene air is hurtful in many cases of these disorders, though beneficial in some cases of asthma ; its opposites inflammable, azotic, and fixed air, seem then to be those which are most likely to be useful in phthisis : But there are also substances which some eminent physicians have thought might be usefully employed even in the state of powder, such as Peruvian bark, the calces of lead and zinc, with other astringents.

To the use of powders, however finely *mechanically* divided, I think there are some objections ; particularly I doubt whether they could enter the minute vesicles of the lungs ; but if such substances can be *chemically* divided and obtained in the state of solution in air of some congenial species, they might have their full effect.

It is well known, that inflammable air, when produced by the common process from iron and vitriolic acid, always carries with it, even through water, a large quantity of iron ; some of which it afterwards deposits, but very probably some part still remains suspended. If iron should be then esteemed a proper medicine for disorders of the lungs ; we are thus furnished with the means of obtaining in a sufficiently divided state ; and to free it from any adherent acid, it may be passed through a caustic alkali.

If the calx of zinc is thought preferable, it is suspended in inflammable air in great quantities, by applying water or steam to red hot zinc in close vessels, and probably also by the common process of making inflammable air from zinc by vitriolic acid. The calces of zinc are very efficacious in healing external sores; and are very likely to be so in internal ones, provided they can be applied, as I think they may, by the means indicated.

Charcoal has lately been found extremely efficacious in correcting putridity, and in disposing ulcers to heal. It seems to me, that no substance is dissolved in inflammable air in such quantities as charcoal, nor more intimately united. If water is applied to red hot charcoal in close vessels, the heavy inflammable air is produced in large quantities; and this air has been found to contain inflammable air, properly so called, fixed air, separable by water or by alkalies, and some other substance, which, when the inflammable air is deflagrated with oxygene air, produces fixed air. This substance I consider as charcoal in a state of solution; for were it fixed air completely formed, it would be separated by the means mentioned. Whether charcoal in this state could be decomposed by any excess of oxygene in the blood of consumptive patients, I cannot say; but it seems likely that it would; and at any rate it would act as charcoal powder does, and therefore highly merits trial.—[Since this was written, these conjectures have been verified; no species of air having been found so effectual in phthical cases as the heavy inflammable air.]

As fixed air is a saturated solution of charcoal in oxygene air, it is not probable that the lungs can decompose it; we should therefore only look to its

effects as an antiseptic. As the lungs, when doing their duty, should separate, and throw out fixed air, it is not probable they will absorb it, though it may have some effect merely by excluding the oxygene of the common air.—[It seems now certain that the lungs can absorb fixed air in toto, and that it changes the state of the blood.]—I think, however, it will be found to have most beneficial effects in cases of a putrescent tendency; or if you do not like this theoretical phrase, where the breath and expectorated matter are scetid. The species I would recommend is that from fermentation, and the means, keeping a vessel of fermenting wort close by the patient, which will in general be found grateful to him.* Fixed air, from vitriolic acid and calcareous earths, may be occasionally much contaminated by other acids. The oil of vitriol of commerce is generally impure, containing sulphureous acid, with the nitrous and marine; it should be rectified for the purpose of medicine.

If it be certain that butchers are exempt from phthisis, putrid animal effluvia may be useful; and if the matter which constitutes the smell be not the useful part, it may be corrected by powder of charcoal, which does not otherwise hinder the progress of putrefaction. The smell seems to be owing to ammoniacal hepatic air,

The mixture of azotic and fixed air to be obtained from burning charcoal (first freed from bitumen by heat) might be tried, but I should hope more from the heavy inflammable air of charcoal,

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* I know that Mr. W. speaks here from attentive observation.—T. B.

The oxygene air may also be impregnated with various substances. When it is made by passing the steams of *sp. nitri* through a red hot tobacco-pipe, it is highly charged with a white powder, some part of which it lays down on the contact of water: when produced in glass vessels, I have never seen it contain any such white matter. An eminent physician of your acquaintance, previous to my mentioning to him the ideas I now send you, observed to me, that the oxygene air from heated manganese, had a peculiar taste and smell; and that unless some other facts led to ascertain the subject, he should be at a loss to determine whether some of the cures you mention *might* not be attributed as much to the manganese as to the oxygene. He also, *a priori*, had entertained ideas of the good effects of substances dissolved in airs.

It would seem that the more pure the oxygene air can be obtained, so much the fitter it is for medicine, but the facts here mentioned may serve as cautions, as to the substances from which it should be obtained.

In regard to the manner of breathing these medicinal airs, I think it will be done best from bags of some very flexible and light substances, such as very thin leather waxed, or oiled silk. If a small tube be inserted into the mouth of the bag, the air may be pressed out opposite the patient's mouth, in cases when they are too weak to make extraordinary exertions of the lungs, or rooms may be filled with the proper mixture of airs.

It would be desirable that a list were made out of all substances, which are known to be soluble in air of any kind, or are of themselves reducible to vapour or steam,

steam, that experiments may be made upon their sanative effects in cases of diseased lungs. The list will prove more numerous than may appear at first glance.

Having now explained my general ideas, I submit them to your correction.

And remain, &c.

J. W.



July 14, 1794,

DEAR SIR,

I send you with this, drawings of my apparatus for producing and receiving the various airs which may be supposed to be useful in Medicine, with a description or explanation of the apparatus, which if you think it worthy publication, I hope may at least prompt some younger and more active man to conceive a better.

In consequence of your desire, Boulton and Watt have agreed to manufacture these machines for the public. We have no desire to be the manufacturers, except to supply those who may not have the same opportunities as ourselves of procuring them; the price shall therefore be as moderate as we can make it; and those who choose to have them made by others, see what is to be done.—Wishing you to be successful in this undertaking, which promises to be of so much utility to mankind.

I remain, &c.

J. W.

To Dr. Beddoes.

Sept. 2, 1794.

DEAR SIR,

You desire me to send you a more particular account of my observations on the medical airs than was contained in my former correspondence on that subject. In my letter of June 17th, I mentioned that it seemed to me that the heavy inflammable air, or carbonated hydrogen, being principally a solution of charcoal in inflammable air, was more likely than any other to correct any disease arising from super-oxygenation of the blood. I could not, however, foresee that its effects would be so powerful in some respects as they have proved. In the beginning of July, I made some of this air by the application of water to red hot charcoal in a close vessel. Its smell was somewhat hepatick, from the new cast iron vessel it was made in, and was also contaminated, by a bad lintseed oil varnish in the refrigeratory, its taste was that of fixed air, though more feeble. I inhaled a little of it cautiously, but had scarce withdrawn the pipe from my mouth before I became so giddy, that I could not stand without a support. I had also considerable nausea. A healthy young man, who stood about 6 feet from the hydraulic bellows when I discharged about a cubic foot of this air, was effected in the same manner, as it passed by him towards an open door. Another young person, merely from smelling to it as it issued from the bellows, fell upon the floor insensible, and wondered where he was when he awaked. None of us experienced any disagreeable effects in consequence of the vertigo, &c. only in going to bed six hours afterwards, I felt some small remains of the vertigo. Several other persons have inhaled it since; and all were affected in the same manner. I have no doubt, from
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what I have observed, that if inhaled in a pure state, this air would speedily bring on fainting and death; when given as medicine, it ought therefore to be much diluted with common air, I should think with 12 times its bulk. Its effects upon diseased lungs you are better qualified to speak to, and I trust you will give the necessary cautions for the use of so active a medicine, in a more distinct manner than I am qualified to do.

About the same time, I made some inflammable air by means of zinc; it contained a very considerable quantity of the flowers of that metal in a state of suspension, which had the appearance of grey smoke, as it was discharged from the bellows. I breathed this air 3 or 4 times without being sensible of any immediate effect; nor could I have distinguished it in that manner from common air, though when I blew it out of my lungs against a lighted paper match, it took fire. Next morning I spit up some mucus very solid, and as moist as elastick as caoutchouc, and the same in a smaller degree the second morning; this I attributed to the calx of zinc, which I apprehend it contains in a state of solution, as well as of suspension.

Of fixed air, I have little to say. I have occasionally breathed it in larger quantities than were agreeable, and always experienced flying stitches in the muscles of my breast in consequence, but they soon left me without any medicinal help.

Considering that no species of artificial air is obtained except water is obviously present, or that there is reason to suspect it may be contained as an element, or part of one of the substances concerned, and that Dr. Priestley obtained fixed air from aerated barytes, by passing steam over it when in a red hot state, though
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it would yield none by a mere dry heat, I concluded, that if water or steam were applied to calcareous earths when red hot, they would readily part with their fixed air. I put $1\frac{1}{2}$ lb. of chalk broken into small pieces into the pot of my apparatus, and, when red hot, admitted small quantities of water. I obtained about 4 cubic feet of fixed air, extremely pungent to the smell, and greedily absorbed by water. The last portion was fixed with some inflammable air from the iron pot, and the chalk was found to be nearly caustic, but had no way changed its form.

This air was free from any smell similar to that of aquafortis, which that produced by means of vitriolic acid generally has, and perhaps was more pure.

In pursuance of the same idea, I concluded that nitre might yield its dephlogisticated air less reluctantly, if water were added when it was red hot. I put 4 ounces of nitre into an iron pot, and, by mere heat, obtained about 400 cubic inches of air, which being washed in its passage through the spiral refrigeratory, did not taste of spirit of nitre, though it smelled slightly of it. Fearing that on the addition of water some inflammable air might be produced, and there might be an explosion, I removed the refrigeratory and bellows, and then admitted some water. Air immediately issued in quantities from the conducting pipe of the pot; and this air was found, on the application of a match, to be dephlogisticated; but some spirit of nitre issued at the same time, and probably some azotic air. The pot was considerably corroded by the nitre, which had found an issue at some defective places, that has hitherto prevented a more complete experiment from
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being made. It would seem, from these appearances, that my reasoning was right, and that nitre may in this way be made to yield all its air in a moderate heat. It still, however, remains a desideratum to find vessels which can retain in it a red heat for a sufficient time.

I put $1\frac{1}{2}$ pound of the Mendip manganese you were so kind as to send me, into the iron pot, and, by dry heat, obtained from it about $1\frac{1}{2}$ cubic foot of air ; the first and last portions seemed, by the taste, and by its extinguishing flame, to be fixed air, about half a cubic foot was dephlogisticated. When it had ceased to give air by the heat, I added water, and obtained a considerable quantity of fixed air, similar to that from chalk, but in which a grey powder was suspended in considerable quantities, which gave the appearance of smoke, as it is issued from the bellows. A person who breathed a little of this air undiluted, experienced a slight vertigo and nausea. May not this proceed from the powder suspended in it ?

The purity of the dephlogisticated air, which you obtained by means of vitriolic acid from the Exeter manganese, may not be wholly owing to its superior purity, but to your mode of disengaging it ; for I apprehend concentrated vitriolic acid will disengage very little fixed air, even from marble, as it soon covers it with a coat of gypsum, which protects it from any further action of the acid. If, therefore, this air can be freed sufficiently from any taint of the acid, the method you have followed seems by much the best mode of obtaining it, and perhaps the cheapest.

In respect of pure azotic air, I have tried no processes, but the method I mentioned to you in June
last,

last, of obtaining a mixture of azotic and fixed air from burning charcoal succeeded perfectly.

I made a chaffing dish about 6 inches diameter, and nine inches deep, into one side of which, near its middle, there was inserted a pipe one inch diameter; to this pipe was joined another about 3 feet long, passing through a trough filled with water, and connected with the hydraulic bellows, the latter being slowly elevated, were filled with the air which had passed through the burning charcoal in the chaffing dish, and this air, upon being poured out of a cup over a lighted candle, extinguished it immediately. Large inhalations were made of it by some of my assistants, without injury to themselves; but, upon me, it produced effects similar to those of fixed air. Its uses in medicine I cannot pretend to predict; but if azotic air is found useful, this may be given in any case, wherein fixed air will be hurtful.

I remain, &c.

J. W.

To Dr. Beddoes.



I have just made an air, which, as it has great powers, may, for ought I know, have great virtues; my experience extends only to its bad qualities—*Pyro-farcate*. I put 2 oz. of lean beef in the fire tube and obtained, by mere heat, 250 c. i. of air, highly fœtid, like an extinguished tobacco pipe; inflammable, with a very blue flame; little diminished by lime and water.—*Pyr-hydro-farcate*, on adding water to the red hot charcoal of this beef, I obtained 600 c. i. of air, with a fœtor not so bad as the other; burning with an orange-coloured flame; losing not quite $\frac{1}{3}$ in lime water,

ter. The smell of the first made me sick, though I did not inspire any purposely, and not above one third of the quantity mentioned was let loose in my laboratory, and 3 doors and a chimney were open; we were, however obliged to leave the place for some time. The P. H. sarcate seemed to possess the same property, but was more cautiously treated. G. was giddy all the afternoon. *Pyro-Comate*. Next day, 2 oz. of woollen rags were put into the tube; they gave, by mere heat, 800 c. i. of air; fœtid, though not so offensive as the other; burning with a deep blue flame; not tried with lime and water. — *Pry-hydro-comate*, by addition of water to the red hot charcoal, gave above $1\frac{1}{2}$ cubic foot of air fœtid, but more like vol. alkali in smell—burning with a yellow flame; losing $\frac{1}{5}$ th by washing with lime and water; part was undoubtedly alkaline air and absorbed by the water; the water in the refrigeratory was strongly impregnated with fœtid vol. alkali. Though none of either of the airs was inspired, that could be avoided, I had a slight, though uncommon, nausea, attended with some elevation of spirits, all that evening, but no heat or thirst. In short, it was very like the effect of the fumes of tobacco on an unexperienced person: In bed I was restless, though without pain or particular uneasiness, I could not sleep. Next day the nausea, and some giddiness, continued, or rather increased, and a head-ache come on.—The uses of this air, if it has any, I leave you to find out. I think I shall have no more to do with it, or with animal substances: One may discover, by accident, the air which causes typhus, or some worse disorder, and suffer for it.

JAMES WATT.

October 7, 1794.

XX. Facts

XX. *Facts and conjectures respecting the medicinal use of certain solid and liquid substances.*

Extracts of letters from Dr. GARNET.

SIR,

Were we possessed of methods of increasing or diminishing the quantity of oxygene in the system, we should have advanced a great way towards the cure of several formidable diseases. The method of doing this by inspiration is ingeniously conceived, and may, where recourse can be had to it, answer the purposes, but perhaps cannot be generally used.—In considering this subject in the course of the last year, the following question occurred to me: *when oxygene exists in the system in too great a quantity, may not its quantity be easily and successfully diminished by liver of sulphur exhibited by the mouth?* When this substance is moistened with water, the water is decomposed; the oxygene uniting with the sulphur, and forming sulphuric acid, while its hydrogen is disengaged in large quantity, which dissolving a portion of the sulphur, forms sulphurated hydrogen gas, which will be readily dissolved by the chyle and conveyed into the blood. It is well known that hydrogen, at a much lower temperature than that of the human body, has a strong attraction for oxygene, with which it unites and forms water; and I have scarcely a doubt that this will take place when the sulphurated hydrogen is taken into the blood; and from some experiments which I have made, I even suspect that the quantity of oxygene in the blood might be so far diminished by means of liver of sulphur, that a real scurvy would be produced. If

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I am right, will not this prove one of the most effectual remedies in florid consumption, as well as some other diseases which depend upon too great a quantity of oxygene in the blood? That the kali sulphuratum is a powerful medicine, I have been fully convinced in cases where I have given it to stop or lessen a salivation which has been brought on by mercury. In these cases I have several times tried it, and have never seen it fail; and in 24, or at most 48 hours after the first exhibition of this remedy, the salivation is much abated. I suppose that the mercury derives most of its activity from its being in the state of an oxid, for crude mercury possesses little or no power.* On the decomposition of the water in which the medicine is given by the kali sulphuratum, sulphurated hydrogen gas is produced and conveyed into the blood, where the hydrogen unites with the oxygene of the acid menstruum of the mercury, and forms water; while the sulphur will convert the mercury into an ethiops which is very inert.—The benefit derived from hepatised waters, and from kali sulphuratum in *colica pictonum*, some instances of which I have noticed in the last edition of my treatise on the Harrowgate waters, shows the great power of sulphurated hydrogen gas, which probably renders the lead as well as the mercury inert.

The last winter, during frosty weather, I walked a good deal for several days. I at first found no bad effects from this exercise, but my spirits were remarkably good, and I found myself less affected by cold than usual. My friends, however observed, that my countenance (which is naturally inclined to red) was more florid

* In the form of mercurial ointment, the mercury is evidently oxygenated by continued friction.

florid than usual. In a few days I was seized with a difficulty of breathing, great tightness in my breast, and a short dry cough: I tried several remedies generally made use of, such as inhaling the vapour of water, blisters, opiates, &c. without relief. On reflecting that having used almost constant exercise, for many days, a much greater quantity of oxygene than usual would be taken into the lungs by the increased action of inspiration, (probably more than the increased muscular exertion required), and likewise that the barometer was very high,) and the air very cold at that time, both which circumstances would occasion the presence of a greater quantity of oxygene in a given *bulk* of air, I imagined that my system was superoxygenated. I began with taking about half a drachm of kali sulphuratum dissolved in water every two hours,—likewise dissolving the same quantity in boiling water, and inhaling the vapours from it by means of Mudge's machine every hour. Before twenty hours had elapsed, I found the sense of tightness in the thorax considerably lessened, some degree of expectoration came on, and the cough was much relieved. In three days, by pursuing this method, my countenance became considerably paler, and I found myself perfectly free from any complaint. Since that time I have prescribed the kali sulphuratum in several cases of florid consumption, and with considerable relief; and in some other cases where there were evident marks of superoxygenation. In several of these cases I have ordered a mixture of the kali sulph. and powder of charcoal, thinking if the charcoal could be conveyed into the blood, it might assist in diminishing the quantity of oxygene, by uniting with it, and forming carbonic acid; at any rate, I thought that it might diminish the quantity of

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oxygene

oxygene in the primæ viæ, and thus assist the sulphurated hydrogen, by permitting a greater quantity of that gas to be conveyed into the blood ; but whether it really does produce any good effects, I cannot positively say. That sulphurated hydrogen gas is conveyed into the blood, and that either it or its sulphur is given out by the excretorics, is, I think, evident from the urine of persons who have drank the sulphur water at this place, immediately rendering visible characters written upon paper with a solution of sugar of lead, on such paper being immersed in it : and likewise from such persons finding their watches and the silver in their pockets tarnished during the time they are drinking the water, though they do not at the same time use the bath. If you wish for an account of the cases of consumption in which I exhibited the kali sulphuratum, I will send them.

When deficiency of oxygene occurs, as is the case in scurvy, typhus, &c. may not the oxygenated muriatic acid be used with great advantage, or perhaps the oxygenated muriat of pot-ash would be still better. We have here a large quantity of oxygene loosely attached to the salt, which would probably be soon separated by the blood. Sir W. Fordyce's account of the efficacy of the oxygenated muriatic acid in typhus, strongly supports the opinion.

I am, &c.

THOMAS GARNET.

Harrowgate, Dec. 13th, 1794.

SIR,

SIR,

In the month of February, 1794, I was desired to visit Mr. L. of Knareborough.—I found him extremely emaciated; he had a short dry cough, with very little expectoration; and the little which he expectorated was of the consistence of cream cheese; he complained constantly of a pain in the left side. His face, though pale, had a circumscribed spot on each cheek, of a fine florid colour; his tongue and lips were likewise very florid; he had cold colliquative sweats every night; his pulse, though small, was *sharp*, beating like a stretched cord, and he had a considerable degree of fever with exacerbations twice a day; his body was rather costive; his hair came off in great quantity on passing a comb through it, and his nails had in a great degree the curved appearance described by authors; in short, there was present every symptom characteristic of phthisis. He had been first attacked with these complaints about nine months before I saw him; they came on with symptoms of common catarrh. The expectoration was very considerable about six weeks before I saw him, mixed with streaks of blood, and remarkably *foetid*. This discharge had gradually lessened, and become more consistent, attended with an increased difficulty of breathing, and pain of his side. I found upon inquiry that he was of a scrophulous family; and he told me that he was the only survivor of a large family, his brothers and sisters having all died consumptive. Before I saw him, most of the remedies generally used in such cases had been applied. Blistering, bleeding, myrrh, &c. had given him no relief, and his symptoms seemed aggravated by the bark and opium, which last, though given in doses of from one to three grains,

produced not the least effect upon his troublesome cough. I directed him to take a drachm of kali sulphuratum, mixed with half a drachm of powdered charcoal four times a day in tea, and besides to put a tea-spoonful of kali sulphuratum into Mudge's inhaler, pour boiling water upon it, and inhale the vapour for a quarter of an hour at a time twice a day. When he had pursued these methods for two days, his breathing was sensibly relieved, and his cough was by no means so troublesome; he expectorated more freely, and what he expectorated had more the appearance of bland pus. In a few days the expectoration became much less considerable and fluid; the hectic fever was less marked; the cough was much easier; he slept tolerably at night; and the florid spots on his face had nearly disappeared. His pulse, though still 120, was much more soft; and though the perspiration was free in the night, the sweats were not cold and partial as before; his appetite was better, and his bowels quite regular. Encouraged by these appearances, I desired him to persist. In about a fortnight he found himself so much stronger, as to be able to walk about the room five minutes at a time, several times a day. One day during my absence, being told that the weather was very fine, and the air very warm for the season, he expressed a great wish to walk out, and continued in the open air for near two hours. In the evening the cough and pain of the side returned, and were more troublesome than ever; he expectorated with difficulty, and in very small quantity; the flushing of his face and sweats returned. The powders were again had recourse to, but did not afford much relief, though the expectoration became rather more easy. Blisters and opiates did not cause any alleviation;

tion; a diarrhœa came on, and after languishing about a week, he died. When I first visited him, he had been given over by his apothecary, who had left him, declaring that he did not think he could live till the morning. I myself did not think he could survive above a day or two.

April, 94.—I visited — Byron, of Knareborough, aged about 40, of a strong habit of body, and in general healthy. — After hard labour for some days in cold weather, he was seized with a difficulty of breathing, a short dry cough with but little expectoration, a great sense of heat, and face uncommonly florid; he was very restless and slept none; his pulse was 96, and rather full, and he had some pain in his right side. I directed about ten ounces of blood to be taken from the arm, and the application of a blister to the pained side, but he was not in the least relieved by them; the blood drawn was remarkably florid. In the evening I directed him to take a draught with 25 drops of laudanum, in hopes of relieving his cough, and procuring some sleep, but it did not produce the desired effect, he having a very restless night. Suspecting from appearances that the system was superoxygenated, I directed him to take a drachm of kali sulphuratum four times a day in a little tea. He took it four times the first day, thought himself somewhat relieved in the evening, slept better than he had done for several nights, his cough was much easier in the morning, he expectorated a little more freely, and the pain in the side was gone. He persisted in this plan two days more, and then found himself perfectly well. — An ingenious young friend of mine, Mr. George Birbeck, who is now a student at Edinburgh, was on a visit with me at the time, saw the patient along with me, and was surprised at

at the quickness of the cure. Similar cases are often met with among labouring people in this pure air; and I must own that they have often perplexed me. I have generally found that no remedy affords permanent relief; but that the disease gradually goes off in ten days or a fortnight, if the patient will confine himself to his chamber, and more particularly to his bed. I hope, however, that I have it now in my power to shorten its duration. No doubt if the patient could have an opportunity of inhaling hydrogen gas, it would also remove the complaint.

I am Your's, &c.



*Letter from Mr. SANDFORD,
On the internal use of charcoal.*

DEAR SIR,

As every additional fact in support of a practice which (if we may judge from the rapid sale of publications on pneumatic medicine) begins to be generally known, if not adopted, may induce medical men to extend their experiments, the two following observations are at your service for the new edition of your pamphlet.

S. C. æt. 34, has been for upwards of three years affected with a carcinoma of the *os uteri*, and has scarcely ever for a long time past been free from pain, attended by a most fœtid discharge. She has at different times used fomentations of hemlock, and pills of the same, with opium; but nothing has given her much relief for the last six months preceding the application of charcoal. The charcoal is made into a very stiff
paste

paste with honey; the vagina is filled with this composition the last thing at bed-time; to secure it in its place a soft cloth doubled is applied to the os externum and retained by a T bandage. In the morning the parts are washed by injecting yeast and warm water. Three or four successive applications of this mixture have *always* removed the pain, corrected the fetor, and *frequently* made the patient easy for weeks. More might possibly be done for her by these means if she were not kept in almost constant drudgery by the nature of her occupation. Since the application of charcoal, however, she feels better satisfied in her situation than the preceding three or four years of her life, having been so much less harrassed by her complaints.

A. H. aged 50, of an asthmatic habit, and subject to a severe cough, with expectoration so fetid and gross as to persuade herself and her friends that she is truly consumptive. The cough goes off after expectoration, and on a sudden change of weather returns by paroxysms. She had taken variety of *expectorants* and *anti-spasmodics*. But her symptoms have been far more considerably relieved by a dram of charcoal in fine powder, made into a bolus with honey, taken thrice a day, and washed down with warm milk and water. This eases the cough, and removes the disagreeable smell of the expectoration. It has repeatedly done so in a few days whenever she has had recourse to it. *So far* it has been certainly useful; and she now flatters herself that by longer persisting in its use she shall be completely cured.

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The diseased nose, which was reduced by the application of charcoal,* continues perfectly well; and I cannot help expressing my satisfaction at finding yesterday Dr. Ewart's patient ALFORD (of whom so much has been said in our periodical publications) kept completely easy by carbonic acid air. Next to a radical cure (which in many cases may possibly be effected) it is surely the most desirable of all things to have the means of stopping the progress and keeping off the pain of ulcerated cancers for months, and probably years.

I am, &c.

W. SANDFORD.

Worcester, Jan. 19, 1796.



Letter from Mr. WILLIAM SANDFORD.

Worcester, Feb. 20, 1795.

DEAR SIR,

Among the variety of patients that apply for surgical assistance, those afflicted with putrid ulcers form a principal part; the laws of most hospitals forbid their admission as in-patients; but compassion frequently suspends the operation of these laws; and it is a melancholy truth, that the general poverty, inattention, and improper conduct of out-patients, often counteract the means directed for their relief.

I cannot flatter myself that success will invariably attend the application I am about to recommend for
putrid

* See Mr. Sandford's Account of this interesting case, in CONSIDERATIONS Part III.

putridꝝ ulcers and mortifications; but my own experience has proved it to be efficacious in some of the worst of these cases, and I can add the respectable testimony of my colleagues, Mr. Jeffreys and Mr. Cole. I feel satisfaction in communicating my observations to you as they are fundamentally connected with a system of medical practice, from which you have shewn by experiments, that great expectation may be justly entertained.

Accounts of the good effects arising from the external application of charcoal in a state of combination, or in that of fixed air, have been published by Mr. Justamond, Dr. Percival, Dr. Dobson, and more recently by the ingenious Dr. Ewart, of Bath. Various periodical publications of modern date, have made the efficacy of charcoal in sweetening putrid substances sufficiently known. Dr. Johnstone of this city, informs me, that he has found this singular substance mixed in the proportion of two drachms with two ounces of syrup of roses, to be very speedily efficacious in removing apthous, and putrid ulcerations of the tongue and palate. I have been likewise informed of several cases in which charcoal has been administered with success as an internal medicine.

In private as well as public practice, it has long been customary to apply fermenting mixtures to sphacelated or mortified parts. Mr. Russel and Mr. Jeffreys of this city, whose extensive practice has afforded them many opportunities of observing its effects, assure me (and particularly the former) that they have found no application so generally useful as yeast in every species of mortification, attended with an offensive discharge, except that which Mr. Pott has so well described

scribed as taking place in the extremities of old people. Mr. Jeffreys informs me, that many years ago it was his custom to apply to putrid ulcers stupes wrung out of the common fomentation, and sprinkled with *spiritus mindereri* in a state of effervescence. The effects, he adds, were beneficial; and the books of the Worcester infirmary shew, that he followed this practice in 1751. The late Dr. Cameron and Mr. Edwards also employed it with great success, as far back as 1759. The real efficacy of fermenting applications, depends, perhaps, solely on the quantity of fermenting matter they contain; in other words, of carbonic acid generated, and has no connection with several articles introduced by the fancy of different practitioners.

If the opinion be just, we should expect that the effect of fermenting applications, and of the carrot poultice among the rest, would cease with the production of carbonic acid air; and this really appears to be the case. But by the application of charcoal, not only is the putrid condition of the ulcer corrected, but pus of a more bland nature is generated, the granulations are much quicker in their growth, and the disposition to heal is much quicker after this than after any other dressing I have seen employed. The granulations, indeed, frequently after a short time, become very luxuriant, and require early pressure to suppress their growth.

Putrid ulcers, as I have been credibly informed, have been considerably benefited by charcoal strewed in fine powder on their surface; but of this I cannot speak positively from experience; for the pain which it seemed to occasion on several trials, induced me to lay it aside. and to have recourse to the following cataplasm.

Mix

Mix as much oatmeal and water as appear necessary to form a poultice large enough for the part affected. The consistence, after they are well boiled, should be rather thinner than the state in which poultices are generally applied ; because it is to receive a large quantity of charcoal, which should be very finely powdered and sifted. The charcoal should be added, when the poultice is nearly cool enough to be applied, in such proportion as to give the whole a pretty firm consistence, since after 6 or 8 hours application it becomes very liquid, particularly if the discharge be considerable. The poultice, when made, should be spread upon a soft linen cloth, much larger than the space occupied by the poultice. It will perhaps be thought unnecessary to insist upon equal spreading, or upon making the edges as thick as the centre ; but this precaution is too often neglected.

The poultice, after being properly secured, must be suffered to remain at least 12 hours ; and unless the discharge be great, it need not be removed in less than 24 ; and a fresh poultice should always be in complete readiness before the other is removed ; the part should not be wiped more than necessary, and that the atmosphere might not affect the ulcerated part, the poultice should be applied as quickly as possible.

When the edges are softened and look healthy, when the effluvia are corrected, and good pus appears on the surface, the poultice may be laid aside. Any other application which the surgeon shall think likely to promote cicatrization, may be substituted in its stead. I have experienced nothing more generally useful than to dress the edges with mild cerate, and very plentifully to sprinkle over the face of the ulcer
a fine

a fine powder, composed of two parts of Peruvian bark, one of calcined zinc, and one of myrrh.

In mortifications the poultice must be continued till the sloughs or unsound parts are completely thrown off.—These means, with gentle pressure, generally effect a cure. In one or two instances, where the poultice has been laid aside too early, the ulcers have put on their former ill conditioned appearance, which, however, on returning to the charcoal, has immediately changed for the better. I should not omit to insist with Dr. Cress, on the necessity of carefully preparing, finely powdering, and keeping in clean vessels the charcoal. It adds much to the efficacy of the poultice, if a *very* small quantity of yeast be occasionally spread on its surface.

The following are a few, out of many cases, in which the cataplasm, thus prepared, has been successfully employed. If it be found equal in efficacy to any hitherto imagined, its cheapness seems to give it a claim to be adopted in hospital practice.

CASE I.—T. B. *Æt.* 64, was admitted an in-patient of the Worcester Infirmary, November 23, 1793, as a case that required immediate attention; a mortification of the right leg having taken place, which extended from the middle of the upper part of the foot, to about three inches below the knee; a separation of the unsound parts had in some places commenced, but the discharge, which was slight, was highly offensive and putrid; the back part of the leg, where no ulceration had taken place, was livid, cold, and insensible.

He was immediately put into bed, and the limb laid in a large carminative poultice of the hospital, composed

posed of bay-berries, &c. in which yeast also formed a principal part. The next morning I saw the patient with Dr. John Johnstone; he informed me that he had heard of charcoal having been applied externally to mortified parts with great success; and as he conceived the present case was a favourable one for the trial of its effects, it was immediately applied in the form of poultice, prepared in the manner before described. — Though the leg looked better after the application of the poultice with yeast, yet the change after the charcoal had been twice applied (which it was in the course of 24 hours) was as favourable as it was rapid. By the time the poultice had been 7 or 8 times applied, a compleat separation of the diseased parts took place; bland pus was produced, and the edges of the sound parts appeared healthy and clear; as the application was continued, the leg in the course of a few days lost its livid aspect, and was warmer and more sensible to the touch.

Some of the sloughs, particularly upon the upper part of the limb, when digested clearly off, exposed the tibia; the periosteum sloughed a little, but granulations soon made their appearance, without any exfoliation of the bone; to this part of the leg therefore the poultice was soon discontinued, and mild dressings substituted in its place. The exterior tendons of the foot were laid bare when that part sloughed: but this, as well as other parts of the limb, was soon clear, and presented a healthy and granulating surface; but so large a portion of the true skin having been destroyed by ulceration, *rendered* the healing process long and tedious. The patient, during the first month, took the Peruvian bark in as large doses as his stomach would bear,

bear, together with half a pint *only* of port wine made into negus, in the course of 24 hours; afterwards he was allowed two pints of porter per diem, and his dose of bark was lessened: he was discharged cured, excepting a trifling ulceration upon the instep. — *February 1st, 1794.*

CASE 2.—I. P. æt. 60, came recommended to the Worcester infirmary, as an out-patient, Aug. 2, 1794, for a large putrid ulcer of the left leg, with which he had been afflicted upwards of 4 years; at this time the discharge was so acrimonious as to excoriate the leg in different parts near the ulcer, which was attended with swelling, pain, and inflammation. Being judged in too bad a state to receive much benefit as an out-patient, he was admitted into the infirmary; he took a dose of calomel the night of his admission, and next morning a dose of Glaubers salts, and the ulcer was covered with a thick poultice of charcoal. When the first poultice was removed, which was not till the expiration of 24 hours, the surface of the ulcer appeared more favourable, and the quantity of the discharge was altered for the better; he repeated the dose of calomel and saline purgative twice again within the space of 8 days, and the poultice was renewed every day for a fortnight longer; a large slough was then thrown off from the ulcer, and granulations made their appearance from the bottom, but the edges remained rather callous; these parts were dressed with mercurial ointment, and the face of the ulcer with the astringent powder. The ulcerated part filled up in due time, and the man was discharged perfectly cured. — *October 4.*

CASE

CASE 3.—I. F. æt. 24, a soldier belonging to the Scotch Greys, quartered in this city, was admitted an in-patient of the infirmary October 25, for a large ill-conditioned ulcer of the leg, which was at that time in a very putrid state. Immediately upon his admission, the charcoal poultice was applied. When the slough of the ulcerated part first began to separate, it appeared more deeply attached to the sound parts than any I ever remember to have seen, except in the patient (No. 5) and which was produced by mortification in an old subject; the degree of inflammation in the surrounding parts of the ulcer was very great; he was bled freely, and took saline medicines for some time; the charcoal poultice was applied to the ulcer, and continued till the slough was completely separated and digested off, which took place in about 6 weeks, when the cerate edging and astringent powders were made use of, and would most probably have completed the cure, had the patient paid more regard to his conduct; but having twice absented himself from the infirmary without leave, and coming home intoxicated, I was obliged to discharge him for irregularity. — *December 26.*

CASE 4.—J. I. æt. 24, another soldier belonging to the same regiment, was also admitted an in-patient of the infirmary, November 15, 1793. He had a very large and painful ulcer about the middle of the leg, extending across the tibia, which had been healed at different times, and from flight accidents had broken out again. At this time the edges were callous, and the surface of the ulcer remarkably foul, with a greenish aspect, and attended with considerable inflammation
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of the surrounding parts. The charcoal cataplasm was applied to the ulcer, and he took every third day a solution of Epsom salts for the first fortnight.

The ulcer, soon after the first week, lost its offensive smell, and the surface appeared clearer, but no granulations succeeded, nor were the callous edges at all softened. I then laid aside the poultice, and applied mild digestives, with the gentle pressure of a flannel roller. Still the ulcer continued in a very ill-conditioned state, and without the least sign of further amendment. About this time having some reason to suspect his conduct, and hearing from the nurse of some suspicious circumstances with regard to his linen; upon being questioned, he confessed, that he then laboured under an inveterate venereal complaint.

I then immediately altered my present mode of treatment, gave him mercury by the mouth, and dressed the ulcer with mercurial ointment, which soon produced an appearance for the better.

This case exhibited strong proof of the efficacy of the charcoal, in removing the fœtor, and clearing the surface of the ulcer—more could not *here* be expected from it, for reasons too well known to be alleged.

The man was now made an out-patient, and soon after having some money left him by a relation, he purchased his discharge from the regiment, and I saw no more of him.

CASE 5.—As there are some remarkable circumstances attending the cause that required the application of the charcoal poultice in this case, I shall take
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the liberty to trespass a little upon your time in relating them.

F. M. æt. 60, was brought to the Infirmary Oct. 30, with a simple fracture of the left leg, occasioned by a bull treading upon it, he having unfortunately fallen down whilst endeavouring to secure the animal for slaughter; by which accident the fibula was transversely fractured immediately above its formation of the outer ankle. The accident happened about five miles from Worcester, and his friends, from an over officiousness, which, though well meant, was ill directed, bound a narrow list garter so *very* tight round the fractured part, as to press in the ends of the bone, and act like a tourniquet on the parts below; he was brought in this state to the infirmary 6 or 7 hours after this misfortune had befallen him. The limb below the bandage appeared perfectly livid, and above it, highly inflamed and much swelled. The bandage (which had a little excoriated the skin) was immediately taken off; a saturnine poultice was applied to the leg, and a solution of Epsom salts was ordered to be taken. This was at night; I saw him next morning, and the limb looked then very unfavourably: the poultice was now laid aside, and linen cloths wet with a mixture of spirit minder and spirit of wine were kept constantly upon the part. The day after, vesications appeared near the fracture, with every other appearance of gangrene having taken place; which in the course of a day or two terminated in a large sphacelated ulcer immediately over the fracture, which extended about three or four inches in circumference, discharging a putrid and highly offensive ichor. At this time Dr. Cameron saw him with me, and the

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cortex was given him in the form of cold infusion, with a small quantity of the tincture in each dose; he was also directed to take half a pint of port wine made into negus, in the course of 24 hours. His stomach bearing the present mixture so well, I then gave him a mixture with extract of common oak bark, (*quercus*) a preparation that Dr. R. W. Darwin, some years past, informed me had been applied externally with good effect to scrophulous ulcers; for which purpose I have often found it serviceable; and since that time I have very frequently given it *internally*, in most of these cases where the Peruvian bark seems indicated.

Dr. Lewis remarks, that "an extract made from oak bark, is said by some to be equal in virtue to that of the Peruvian bark."—(*See Lewis's Mat. Medica*, p. 474).

I have experienced equally good effects from this extract, (if joined with an aromatic) as from that of the true Peruvian bark. Some of the physicians of this infirmary have also lately prescribed it with very beneficial effects. With this patient it agreed remarkably well, improved his appetite, and supported his strength, which had been greatly reduced. This man's case seemed to prove, as clearly as any I have met with, the ingenious theory advanced by the late Mr. Hunter, that the "mortification which is preceded by inflammation, is produced and accompanied with increase of action and loss of power."—(*See Hunter on the Blood, Inflammation, &c.*)—Hence the necessity of giving the cortex, or some similar tonic, in as large doses as the stomach will bear, and no more alcohol in any form than is merely sufficient to keep up the *necessary* action, and thereby prevent its *excess*.

But

But to return to the situation of the limb—the same day the bark was administered internally, the charcoal cataplasm was applied to the mortified parts, and daily renewed at first twice, and latterly only once in the 24 hours, till the whole of the slough, which was large and deep, was entirely separated and thrown off. When this was effected, the fibula was laid bare, and the fractured part exposed to view; it was then of course to be treated as a compound fracture, and cured by the second intention; the poultice was now discontinued; the edges of the ulceration dressed with epulotic cerate, and the centre with dossils of lint dipped in a mixture composed of equal parts of *mel. rosar. tinct. myrrh*, and *decoct. cortic. Peruv.* Granulations soon appeared; a slight exfoliation took place, and the cure went on perfectly well. The man is now able to walk about with the assistance of a stick, and the motion of the foot (which I feared would have been destroyed by suppuration) has been fortunately preserved, and is recovering its action.

CASE 6.—J. H. æt. 27, was admitted an in-patient November 15, 1794, having a large putrid ulcer of the right leg, about the middle, and across the tibia; he had been afflicted with it for more than two years, and it had been in its present ill-conditioned state upwards of three months; he had dressed it with variety of unguents of different kinds, and at this time it had every appearance of approaching gangrene. The charcoal poultice was immediately applied to the ulcer, and he took the extract of oak bark in the proportion of 15 grains to an ounce and half of saline mixture; to each dose of which $1\frac{1}{4}$ drachm of aromatic tincture was added every six hours. This plan he continued with little alteration for upwards of a month before the slough

was completely separated ; when this was thrown off, the poultice was laid aside, and the ulcer treated as before mentioned. The ulcer, from the luxuriance of its granulations, required the pressure of lead to assist in the cicatrization.

CASE 7.—(Mr. Cole's patient).—O. C. æt. 20, was admitted an in-patient of the infirmary, for a compound dislocation of the ankle, which had been in so bad a state for some time previous to his admission, that it was judged necessary to amputate the leg, which was accordingly removed at the usual part below the knee. The man underwent the operation very well. The lips of the stump were brought together by strips of adhesive plaster, to be healed (as is now generally practised, I believe) by the first intention.

Four days after the operation, the stump and thigh appeared much swelled, though the bandages were by no means tight. I happened to be in the ward when Mr. Cole removed the dressings, and examined the stump, the lips of which had receded, and exposed the face of the stump, which we were surprized to find in an highly offensive and gangrenous state ; added to this unpleasant appearance, the patient's countenance was pale and sunk, and his pulse quick and tremulous.

Mr. Cole immediately ordered him a saline mixture with the cortex, and port wine negus occasionally ; a thick charcoal poultice was also applied to the face of the stump. In less than 48 hours every unpleasant appearance was changed for the better, a good digestion came on, and the cure was by these untavourable circumstances protracted for a short time. The patient soon lost his fever ; recovered his strength ; and the stump did well.

In this case, it was not found necessary to continue the charcoal poultice for a longer time than three or four days.

Having informed Mr. Field, who attends the invalids in the house of industry lately established in this city, of the good effects of the charcoal applications, he has in consequence applied it to several putrid ulcers of the legs, &c.—in subjects from whose age and other infirmities, little hope of relief was to be expected.

He assures me it has *never failed* to effect a speedy and favourable change, by correcting the putrid discharge, and producing healthy granulations, with a bland and well digested pus.

Two of the cases in which he has applied it I think merit particular attention. The one was a cancerous ulcer of the side (the breast having been removed several years past at the infirmary) extending deep under the axilla. Mr. Field applied the charcoal in *fine powder*, which he sprinkled very freely over the face of the ulcer, first smearing it with a very small quantity of yeast. In a few days it removed a most offensive fætor, and procured a healthy aspect of the ulcer, with a discharge of mild and inoffensive matter. The arm of this patient on the diseased side, after swelling to an enormous size, became gangrenous, and a mortification succeeded, with putrid and deep sloughs from the wrist to the elbow; the same mode of application was adopted with the hope of removing the intolerable fætor. Though it was conceived the patient could not live many days, being upwards of 60 years of age, and very much reduced by the pain and long continued discharge of the ulceration, the progress, however, of
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the mortification, which seemed extending upwards toward the shoulder was immediately checked ; in a very few days the sloughs completely separated, leaving healthy granulations, and the wound, though a very large one, is filling up as kindly as could be expected in a younger or healthier subject.

The other was a woman upwards of 50, who, from long confinement to bed, and the effect of constant and unequal pressure, had a deep slough formed upon one of the nates, which was dry, perfectly insensible, and without any disposition to suppuration.

The charcoal powder was applied here as in the former case, and retained by a large piece of leather, the edges of which were spread with adhesive plaister ; in less than a week a complete separation had taken place, when a dressing of mild digestive effected an easy and speedy cure.

In neither of these cases did the patients complain of any increase of pain from the application.

No medicine was given to the last ; and in the first case nothing more than a few grains of extr. cicutaë, with about 20 drops of tincture of opium at bed-time.

In some cases in which I am now applying charcoal powder, no pain has ensued. The yeast has been added in these cases ; and it operates as effectually as the cataplasma.

Believe me, dear Sir, &c. &c.

WILLIAM SANDFORD.

To Dr. Beddoes.

Letter

Letter from Dr. JOHN JOHNSTONE.

Birmingham, Feb. 14, 1795.

DEAR SIR,

Herewith I send you an abstract of trials of some of the chemical substances ; I began to make them early in the year 1793, after having seen the relations of M. Lowitz and Kels. Many of the experiments of both these gentlemen I repeated, and others were instituted to satisfy my mind on some topics relating to putrefaction, a subject till lately involved in much darkness, and concerning which, our knowledge at present is far from precise.

Long before the time of M. Kels, Macbride had discovered, that the aerial product of fermentation, rectified the smell and taste of putrifying bodies ; and there are many accounts of its service in diseases, recorded in the 4th vol. of Priestley on air, and in Dobson's Commentary. But this power, though possessed universally by the carbonic principle, is not confined to it. Substances containing oxygene, have it probably in a greater degree. Half an ounce of nitre will produce a more instantaneous effect on the same quantities of putrid fluids or flesh, than an ounce of powdered charcoal. The same holds good with respect to many other oxygenated substances. The hyper-oxygenated acids, destroy putrid smells, in very small proportion.

By these leading facts, and by many others which it is unnecessary to detail, I conceived myself authorized to make trial of the subjects of them, in cases of diseases which seemed to bear any affinity to the process
of

of putrefaction. These trials I shall here class together, without any respect to the order of time in which they were made, though many of them were made or improved, since I came to this place in the last Autumn, in conjunction with my brother, Dr. Edward Johnstone.

ULCERATIONS. — In hardly one case of foul ulceration of the extremities have I been disappointed in the application of carbon, though it has been applied in a vast number of cases under my inspection. Whether in the form of powder or of liquid (yeast), it universally renders them clean. In the case of Nurse Purton, an old woman of 80, a patient in the Worcester infirmary, and who had been afflicted with a fore leg for almost half a century, the carbon cataplasm never failed to cleanse the wound, though the application sometimes gave pain.

During the Autumn of last year the measles assumed a peculiarly putrid appearance in the town of Birmingham and its neighbourhood. Children were generally affected with a very offensive and obstinate diarrhœa, during their continuance, and towards the close of the disease with very foul ulcerations, spreading about the face and mouth. In the case of a girl of 8 years old, the right cheek was much swelled, and the inside of the mouth was occupied by a foul spreading ulcer. Various unguents had been tried in vain, the ulcer spread, became black, and every day assumed a worse appearance. The change for the better was very quick after the application of the carbon, and the ulcer soon healed. From the same cause, the roof of the mouth, and the upper gum of an infant were in a dreadful state, in part eaten away, and excessively foul. A paste
composed

composed of charcoal powder and yeast was ordered to be applied, and was effectual in healing the wound, though the structure of the parts will probably be never entirely restored.

In two cases of mortification, one of the leg in a man of fifty, the other in the thigh of a young boy, the application of the carbon was most satisfactory. In the first case the wound extended all over the foot and nearly up the leg: The sloughs began to separate the next day after the application. In the case of the boy the separation of the sloughs was succeeded by universal erysipelas. Both patients took bark and I believe nitre internally, and both recovered.

To scrophulous ulcers I have applied carbon in several cases, as well as given it internally, but never with permanent benefit. I have also given these patients nitre in large doses, at the same time that the ulcers were covered with carbon, and with no better apparent effect.

CANCER.—In one case in which a cancer occupied the whole breast, and had spread towards the neck, eating it into foul ulcerations, the carbon powder was applied. The appearance of the wound was much mended; it became clearer and looked redder, but no permanent relief was obtained; and sometimes there was a great deal of pain.

In a cancer of the os uteri, after various trials, I directed a paste composed of carbon powder and yeast to be applied by a pessary to the part. There was some inconvenience in the application, though the patient complained much less of it than of the fumes of cinabar,

nabar, which had been previously administered. She could not be prevailed upon to persist in its use.

CUTANEOUS ERUPTIONS.—The face of Poole, a patient in the Worcester Infirmary, was covered with a dark-coloured reddish blotch, which was painful and spread. Her right arm was covered with the same species of eruption, particularly about the elbow, where there were several sores. She had these complaints many years, sometimes more, and sometimes in a less degree. I directed the carbon cataplasm to her arm, and to wash her face with yeast frequently. The effect was very satisfactory, as she had previously employed mercurials and many other means without benefit. The ulcers healed in a short time, and the eruption in great measure vanished.

In two cases of Erythema without ulceration, after the measles, yeast was applied with the best effect, the eruption disappearing in the course of a day and night.

The progress of pimples upon the face is generally stopped by washing them often with yeast. They grow livid after a few times washing, and soon disappear. I submit it therefore to my fair countrywomen, whether it may not become a much more useful cosmetic than milk of Roses, or of any those doubtful preparations so commonly used.

ERYSIPELAS.—In several cases the carbon was used both by my brother and myself with complete success. In the case of Mrs. H——, it was very threatening, as it spread very much about the face, accompanied with delirium. My brother ordered her face to be washed with yeast frequently, and to take bark internally. She recovered in three days.

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In cases of scarlatina and angina maligna, I now generally direct yeast to be used in gargles, and to be rubbed upon the skin. In repeated instances I have found this plan useful, exhibiting at the same time occasional emetics, with nitrous mixtures.

In phthical cases, when the night sweats were urgent, I have for some time past directed yeast to be taken in the quantity of a large spoonful, or two large spoonfuls in milk, three or four times in the day. It generally appears to be serviceable at first, but I have seldom found its good effects permanent. In one case I think it succeeded.

TYPHUS.—In two instances I had the opportunity of trying the carbon fully.

The first, a soldier, had been very improperly treated with antimonials previously to my seeing him. His debility was extreme with occasional delirium; his tongue black and parched; his stools offensive, and he could keep nothing upon his stomach. The bark in all forms was vomited up. He first of all took a saline effervescent mixture, which staid upon his stomach. He afterwards took one ounce of charcoal powder three times a day, with port wine and water, and 15 drops of laudanum at night. The foulness of his tongue and the vomiting soon disappeared, and he recovered slowly, occasionally taking bark.

In a girl of 14, the small-pox assumed the worst appearances. The eruption began on the third day, with great fever, violent pain of the head and side. A blister was immediately ordered, which gave ease, and she took some opening medicines. The next day, after the blister had arisen, the pustules shewed no elevation,

vation, and every symptom clearly indicated that the disease was in the worst degree. Her stools were offensive, and the debility extreme. I ordered a drachm of charcoal powder to be taken every four hours, with a mixture of decoction of bark and yeast, and that she might have as much port wine as she liked, and fresh ale. This plan was persisted in, with blisters occasionally for nine days, at which time the patient died, with more marks of putrefaction than I ever saw before. Her body was universally black, and at a small distance she looked like a negro. She drank great quantities of the fresh ale, and during the two days before her death, 3 pints of port wine. Purple spots appeared on the thighs about ten days from the beginning of the disease, which vanished on the application of a paste of charcoal and yeast. I much regret that she was not washed all over with yeast, but I confess this circumstance did not occur to me. After the full trial of the carbon in this case so unsuccessfully, I have never trusted to it solely in any of those diseases in which the powers of life are so exhausted as they are in typhus. I believe it may be useful to correct the filth that accumulates in the mouth and in the intestines, but it certainly is not to be trusted to alone for their cure. Substances containing oxygene are infinitely more appropriate for this purpose, and should be employed. Nitre contains oxygene in great abundance, and has been used with advantage in typhus. But its usefulness in inflammatory diseases, and indeed its effects when taken as a poison in large quantity, make me suspect, that the basis of the acid contains a power capable of abstracting from vitality. On this supposition we may account for the contradictory effects ascribed to it. But the consideration should make us
look

look out for other substances that are not contaminated with any powers contrary to those for which we wish to employ them. The oxides of* manganese have occurred to me as likely to answer the end. I have given them in very large doses to healthy persons, and have swallowed them myself without the least apparent injury. On this subject, however, I shall not enlarge, and I will only add one more speculation to what is already perhaps too long.

From the notions that I entertain of the nature of the gout, I have been led to suppose that the inspiration of an atmosphere above the common standard might be serviceable for its cure. If the disease arise in the first place from a deficiency of oxygene in the blood of the arteries of the extremities and the chain of symptoms be induced by this deficiency, certainly an hyper-oxygenated atmosphere is the remedy to be adopted. But this is all hypothetical, and I shall content myself with having given the hint, without pursuing the subject further.

This is what I know of the effects of carbon; it is imperfect as every abstract must be, but it is faithful as far as it goes; and it would have been impossible to have comprehended within the room that you could spare, the cases in their full extent.

I am, dear Sir, &c.

JOHN JOHNSTONE.

* I have been lately informed that Dr. Macdonnell of Belfast has used this oxid with great advantage as an application to certain ulcers. T.P.

DUSTING-BOX.

Several years ago, Dr. Darwin contrived the apparatus, delineated plate 4, fig. 3, with intention to apply substances, that might be supposed capable of a salutary action, to the ulcerated surface of the lungs. The facts in the preceding communications and some others, together with the present disposition of the public to favour attempts towards the cure of consumption induced me to apply for permission to insert a sketch of this little machine in this pamphlet. Whether it will be useful to coat the pulmonary ulcers with fine charcoal, calx of zinc, any of the preparations of lead, Peruvian bark, or some such composition as Mr. Sandford mentions, remains to be tried. The box may be 10 inches high and 8 square. It has within a circular lath brush, with a cross bar of wire, against which the bristles of the brush, loaded with dust, successively strike; the dust is thus spirted up through the mouth-piece, and the patient inhales it at his convenience; and I have lately found that this method may be followed to any extent without coughing being excited. The structure of the box will easily be understood from the plate. On seeing this contrivance, another person thought that a *powder-machine*, formerly more in use for the waste of wheat than at present, would very well answer the purpose; this is represented fig. 4.

Observation on the effect of charcoal, in correcting rancid eructations.—Extract of a letter.

—My dyspepsia was not attended with much flatulence or heartburn, but was very troublesome after eating any strong dish, such as goose, garlic, or cabbage, from a rising of rancid matter from the stomach, perhaps
every

every 5 minutes. This was always *immediately* checked by a table spoonful of very fine ground charcoal—so much so that the next eructation would be scarcely offensive ; and in a little time the stomach was completely set to rights. Several persons in our family have received benefit from it in the same way.

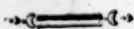
Having had no ailment in the stomach for a long time, I cannot say that I have had *much experience*. — Perhaps I may have been relieved a dozen times, and I think I never took it without a very sensible effect. I do not believe it has much effect on the bowels ; it is aperient however, rather than otherwise. As to your question of prevention of wind, mine was so little a case of flatulency that I cannot speak very positively of its virtue in that particular. It certainly, however, had this effect to a certain degree. Upon the whole, I have not the smallest doubt of it being a very useful family medicine.

I am, your's, &c. — —

To Dr. Beddoes.

I insert this observation with the greater pleasure, from the hope that it might take away one excuse for dram-drinking. I strenuously recommend it to persons whose stomachs are weak ; as also to persons apt to overload a strong stomach, to have in readiness some fine powder of charcoal, and to take it instead of wine or distilled spirit, to prevent food from *repeating*. It may be prepared by burning corks perfectly and throughout black, and then rubbing them to powder. This preparation is used in some places for the cholic in horses ; but as it is given in fermented liquor, its power is somewhat dubious. I have been informed
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by another intelligent correspondent that he has found charcoal gently aperient ; an observation which seems well worth attention.



Mr. Capper's description of his apparatus for experiments on brute animals.

The letters k, l, m, n, pl. 5, represent the wooden chamber, which is dove-tailed to make it air-tight ; the size may be varied according to the size of the animal which is destined for experiment. The one from which the plate is taken, is three inches and a half, by four and a half.

The letters i, j, k, l, represent the mouth-bag, which is of oiled silk nailed on the chamber at b : but before you put them together, glue on a narrow strip of leather ; when the glue is dry, plait the oiled silk ; and as fast as you plait, nail on a narrow strip of leather, similar to the one underneath ; the plaits should be very small, and the nails of course very close to each other. The mouth-bag is easily secured round the mouth of the animal by means of tape, used as a ligature.

The letters m, n, o, G, represent the bag which contains the air to be inspired, and is nailed to the chamber in the same manner as is described. G is the aperture thro' which the bag is filled ; h the inhaling valve (at the bottom of the chamber) made of very thin wood, covered with leather, which being extended on one side farther than the wood, (and this being glued to the chamber), serves as a hinge to the valve. At d is the exhaling

exhaling valve, made and secured (but on the outside of the chamber) in the same manner as the other.

When you fill the bag, the valve at the bottom of the chamber must be pressed down with the finger, to prevent the escape of the air.

At G the silk should be lined with soft leather, otherwise it will soon be worn out by the frequent use of the ligature.

The manner to make the silk air-tight, is by fowing weak leather within the seam, and then covering it with the same, making the needle always pass through the leather between the oiled silk.

W. W. CAPPER,

Query.—Would it not be an improvement if a strip of leather were nailed over the valves, so as not to allow them to turn quite back?—T. B.

XXI. *Recapitulation with some additional miscellaneous facts.*

It appears already that the principles, which had been deduced from the modern experiments on respiration, are too narrow to explain the effects of differently modified atmospheres on the animals, by which they are respired. This is nothing discouraging; for the more various the powers of elastic fluids, the greater, we may hope, will be the resources of pneumatic medicine.—The two instances in which greater toughness of the flesh and tendency in the blood to coagulate were observed after immersion in oxygene air, afforded the pleasing prospect of a physiological discovery; but in an enquiry, where unobserved

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powers

powers may so easily intervene, I have laid it down to myself as a rule of prudence, not to admit any cause, unless the effect should distinctly appear upon four or five repetitions of an experiment with or without variation of accessory circumstances. Two other pairs of rabbits were therefore procured; and one individual of each pair was oxygenated; its fellow being left without preparation, and then both were killed by blows on the back of the head. The difference of coagulation in the blood was the same as in the former experiments; but after boiling I could not satisfy myself that there was any difference in the state of the muscular fibres. One of these rabbits remained in the oxygenic air 20, and the other 25 minutes; the others had only remained 15 minutes. These rabbits seemed as thirsty as the former; one drank eleven times.

Of two white pigeons, seemingly of the same age, one was kept in a vessel of oxygenic, mixed with a third part of atmospheric air for 25 minutes; birds consume air very fast; and at the end of this time, a candle was immediately and repeatedly extinguished on immersion in the vessel, which was the same as that in which the cats had been placed; the pigeon shewed no other sign of distress than a little quickness of breathing; which took place soon after its introduction. The power to stand erect in such an atmosphere, depended probably on the oxygenic it had previously inspired, as in the experiments on drowning. The pigeon was strangled on being taken out of the vessel and quickly opened; the blood coagulated instantly after effusion, and in some of the veins it was already coagulated. The heart was hard and
 inirritable;

inirritable; the cavity of the ventricles was closed; the auricles contained a little coagulated blood; the lungs were florid and appeared inflamed.

The other pigeon was put into a mixture of more than one third atmospheric, with less than two thirds of hydrocarbonate, air. It died in less than half a minute; its speedy death probably arose from the same cause as the rapid consumption of oxygen in the former experiment. No signs of recovery appeared while the feathers were hastily stripped from the belly and breast; the liver as before appeared much more ruddy than in the former pigeon; this undoubtedly depends on the greater proportion of venous blood in the liver than in any other organ; the heart and other viscera were more ruddy in the hydrocarbonated pigeon; the lungs excepted, which were of nearly the same colour in both. The ventricles of the heart were inirritable, and contracted in the hydrocarbonated; but the right auricle was spontaneously acting. The blood was fluid and ruddy; it was some time before it coagulated. The flesh of the heart was remarkably ruddy.

These pigeons being boiled, the hydrocarbonated was universally of a light red; the colour was strongest in the legs; it was well seen in the marrow and spongy part of the bones; the cartilages looked as they sometimes do in the young subject injected: in the breast of the pigeon (which on account of the state of the air when it was taken out of the vessel, I dare not call oxygenated) a degree of redness was perceptible; but the difference was great in favour of the hydrocarbonated: this was throughout as red as a salmon in season; it was observed on occasion of the redness

produced by the same air in the muscles of the thighs in a fowl, that one might have ham and fowl in the same piece. The breast and wings were of a tender pink.—The flesh of the hydrocarbonated pigeon four persons agreed in thinking more agreeably tasted.—In point of tenderness there was no great difference; if any existed, it was perhaps in favour of the latter.

The effect of hydrocarbonate on the blood and flesh was so opposite to all expectation, that I could not be satisfied without repeating the experiment till all fear of an erroneous conclusion vanished. Of a pair of fowls, one was put into carbonic acid air, and one into hydrocarbonate; in the former, the appearances were the same as in drowned and strangled animals, only the liver appeared a shade paler. In the hydrocarbonated, the phenomena were as usual. It was thought by several persons who tasted these fowls after they were boiled, that the flesh of the hydrocarbonated was less consistent; it was said to approach towards the softness of dressed liver.—Of two equal rabbits, one was immersed in such a mixture of atmospheric and hydrocarbonate airs as did not destroy life in 15 minutes; it was then taken out in a state of great debility; both were killed in the usual manner. The blood, liver, and other viscera of the hydroc. rabbit exhibited the accustomed phenomena. The flesh was of a light pink colour when boiled, the marrow of a fine red.

The power therefore of hydrocarbonate air to redden the blood and flesh of animals, made to respire it, either pure or diluted, admits of no doubt. I have attempted to determine the circumstances of its operation, by applying it directly to the blood. In two phials containing one hydrocarbonate, and the other carbonic

carbonic acid air, two funnels were cemented, the necks of which were closed by a wooden stopple. — Blood was received into each funnel as it flowed from a man's vein; when the funnel was full, the stopple was withdrawn and the blood descended into the phials, while the air issued through another small perforation in the cork, which could be closed at pleasure. When the greater part of the blood had descended into the phials, they were stopped, so as on trial to prove air tight. The blood in the phial containing carbonic acid air, acquired no florid colour on its surface; the edges of the coagulum, as they lay against the phial, appeared brighter; but this, upon careful examination, appeared to be owing to their thinness. The hydrocarbonate evidently brightened the upper part of the coagulum to as great a depth as it is usually brightened by oxygene or atmospheric air. The colour was not quite so florid, and yet not a great deal less so. There is, however, a difference in the shade, which to be clearly conceived, requires to be seen.

Three equal and similar vessels were filled, two with hydrocarbonate and one with atmospheric air. Blood was received from the vein of a horse into a funnel, and then suffered to run into these phials. That containing atmospheric air, and one of the others, were immediately stopped and shaken. The blood was observed to acquire a brighter colour throughout; in both cases a head of foam rested upon the surface; and this appeared nearly of the same colour in both; the head was rather brighter than the close and condensed mass, on account of the light transmitted thro' bubbles of air detained in the blood.

Four phials were filled; one with oxygene, one

with hydrocarbonate, one with atmospheric, and one with hydrogenic air from zinc, dissolved in muriatic acid. Blood was received into a funnel from the vein of a horse, and then suffered to run into each of these phials. The blood in the oxygenic and atmospheric airs was equally brightened and to an equal depth; in both the other phials, the surface of the blood was brightened; but more in the hydrocarbonate and to a greater depth. In this the florid colour (which was inferior to that produced by the oxygenic and atmospheric airs) reached three lines in depth; and the rest of the coagulum was less dark than the rest of the coagulum in the hydrogenic; in which the brightened part did not descend more than a line.

The change of colour on the surface of the hydrogenic (which does not I think agree with the observations of some philosophers, who have exposed blood to different airs, but without stating the circumstances of the experiment, particularly the age of the blood) induced me to immerse a third pigeon, nearly the fellow of the two former, in hydrogenic from zinc, dissolving in muriatic acid. The liver appeared rather paler than in pigeons killed in the common manner; but it had nothing like the brightness of the liver in animals destroyed in hydrocarbonate; the veins were of their usual dark colour, and so was the blood. The heart was not ruddy, but it was flaccid; and in this respect formed a remarkable contrast with the hearts of the two other pigeons. The right auricle was working; the ventricles not irritable. The boiled flesh did not sensibly differ from the flesh of pigeons that have inhaled atmospheric air, except, perhaps, in a very slight redness of part of the breast.

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The muscles of the legs, which when they are brown in birds, shew the colouring power of h_{dc}. a. so distinctly, were not at all tinged; nor did the cartilages of the joints look as if beautifully injected; but were pale, as in common cases. Hydrogen, as far as this single experiment warrants the conclusion, has no power to make the flesh of animals tender: and in two or three days the brightened surface of the blood exposed to it grew dark again, and the whole clot ($\frac{1}{2}$ an inch thick) seemed blacker.

To discover the effect of hydrocarbonate on the blood at different periods after venæsection, a portion of the dark coagulum of a horse's blood two days old, was put into a quart of this air, and another part into a quart of atmospheric air. The vessels were equal and similar. A florid coat soon appeared on the blood in the atmospheric air; but no change took place upon the blood in the hydrocarbonate, though it was watched several days. Human blood was put to the same trial nearly as soon as it coagulated, which was within a quarter of an hour after it was drawn: no change in the bottle of h_{dc}. a. — The clotted part of a horse's blood was tried a day after it was drawn; a comparative experiment was made with both oxygen and atmospheric air: these last brightened the surface as usual. The hydrocarbonate produced this effect in a very slight degree: upon the credit of these and some other similar experiments, it may be affirmed that hydrocarbonate air has little power to render blood florid, except it be fluid; but this I think depends on the cohesion it acquires, and not on the life it loses. There is some danger of mistake from hasty observations on the thin edges; I depended

depended principally upon the appearance of the surface, where the mass was such as to produce perfect opacity. Mr. Charles Gimbernat remarked in various instances that more serum separated from the blood in hydroc. a. and that the coagulum formed a much smaller cylinder in the phials containing this air, than in those containing oxygene, atmospheric, hydrogen, or carbonic acid air.

When phials containing hydrocarbonate and blood were opened under water, there was no sign of diminution in the bulk of the air.

Blood being received into a funnel from the arteries of a horse, and transmitted into hydrocarb. the phial was stopped air-tight and shaken; the colour did not become deeper or darker. Venous blood being at the same time treated in the same manner, acquired a colour little less bright than the arterial.

Mr. Watt informs me that he has lately observed pieces of raw flesh keep sweet longer after immersion in hydrocarbonate air.

These facts will suggest a variety of reflections and many new experiments. They seem to disclose the principle on which hydrocarbonate acts in changing the colour of the venous blood. Its effect, so far as colour is concerned, is not destroyed in passing through the small arteries; hence the alteration is seen in the veins, and by consequence in the solids, particularly the liver. This colouring principle (supposing something to be imparted to the blood) differs therefore in its affinity to the animal fibre from oxygene, if oxygene be distributed by the arteries. — Hydrocarbonate
does

does not, as I at first suspected, become explosive after exposure to animal ss. Hydrogen, on the contrary, becomes unexplosive. Whether hydrocarbonate is decomposed or partly absorbed, remains to be determined by nicer instruments than I have it in my power to employ at present.

A florid complexion, may then, it seems from these experiments, as far as it is connected with the mere substance of the blood, depend equally on arterial blood highly oxygenated, or venous blood brightened, as by the application of hydrocarbonate. It may at present be difficult to distinguish the two cases. The blood is frequently florid, as it flows from a vein. But in many of these instances, arterial blood only escapes the change it commonly undergoes in its progress through the small blood-vessels. Thus when Mr. Hunter says, " I bled a lady whose blood at first " was of a dark colour ; but she fainted, and while " she continued in the fit, the colour of the blood " that came from the vein was of a fine scarlet ;" we may suppose the action of the small arteries to have been suspended, and the oxygene not to have been communicated to the solids ; the same when an animal is bleeding to death. Mr. Hewson observes, that the blood from faint animals is brighter and coagulates more speedily ; which may depend on its containing more oxygene. Yet if the rapid coagulation in my experiments was occasioned by oxygene actually present in the venous blood, it was in such quantity as not to brighten the colour,

It might be thought that the oxygene of the blood, forming carbonic acid with hydrocarbonate gives redness ;

ness; but the application of carbonic acid, both to the blood and to the lungs, discountenances this idea. These experiments should be further prosecuted with arterial blood. Meanwhile as it is certain that the blood and the solids may acquire a bright red colour, though not the same shade precisely, from causes totally distinct from the presence of oxygene, my conjectures concerning the condition of the system in some cases of consumption lose their support.—But although I cannot now believe that the permanent redness which I am so much accustomed to see in the fauces in some consumptive patients, and other analagous appearances, indicate hyperoxygenation, I still think it probable that excess of this principle does actually occasion disease. But besides colour, I should require some of the symptoms occasioned by the respiration of too much oxygene to appear, before I admitted this cause. Dr. Garnet has, I think, fixed upon instances of this nature; and perhaps the frequent pleurifies in the Castiles partly depend on the dryness of the atmosphere; a quality which, if it arise from the want of water, and not its combination, implies the presence of more oxygene in a given bulk of air.

The cautions and suggestions respecting the respiration of ox. air, which I had deduced from personal experience, seem confirmed by circumstances in several of the foregoing reports. Elevation of spirits, and power of resisting cold, have oftener than once followed its use; it has also been found to heighten the complexion. Mr. Barr's patient, and Mr. Atwood, furnish striking proof of its power to improve some debilitated constitutions. Both communications afford instruction respecting the dose, which requires
much

much vigilance. In the former of these cases it was necessary to lessen the quantity ; and in Mr. Atwood's interesting journal, though we have unfortunately no precise information on this head, there are particulars that seem to shew that he proceeded to the utmost verge of prudence. These examples will encourage further trial in different sorts and stages of debility. This elastic fluid deserves to be opposed to the approach and to the infirmities of old age, especially where the extremities are habitually cold. A quart inhaled every day, for a few weeks, and repeated from time to time, as the patient's feelings shall direct, bids fair to contribute to the comfort and prolongation of life. Its employment in chlorosis, will, I trust, be continued with success. I am authorized to say, that a remarkable cure of hysteria will be related in the 2d vol. of Mr. Townshend's *Guide to Health*. Its power in the last stage of malignant and nervous fevers ought to be ascertained in the course of another year. Nor is there any thing more urgent than to try it in typhoid or unfluent small-pox : which disorder has raged dreadfully in Bristol this winter, and proved fatal in spite of wine, the yellow bark and opium. I have been prevented by prejudice from ascertaining the effect of oxygene.

In palsy, fact does not yet appear to coincide, as could be wished with expectation. We may very safely put a paralytic patient on a course of oxygene air ; but we should begin with very small doses, and be alive to suspicion. To prevent groundless alarm, I must add, that I have no other reason to give this warning, than what is already before the reader, (see p. 71, 72.)—In paralysis of the absorbents occasioning
anasarca

anasarca of the lower extremities and of the lungs, I have been informed that considerable temporary relief has been afforded. One case has fallen under my own care—it is as follows:—R. G. about 60 years of age, after living freely, had dropfical symptoms. He underwent a long course of violent cathartics, and afterwards came to Bristol Hotwells. The paralytic appearances were so striking, that I declared to his friends, in the most positive terms, that I apprehended he would in no long time die suddenly. The digitalis (which I have never seen to fail in cases of this kind) procured a discharge of the water. It repeatedly collected, and was repeatedly evacuated by the digitalis, and once or twice by squill and the *pulvis ari comp.* The medicines had now no sooner ceased to operate, than a relapse followed, and threatenings of apoplexy were several times observed. At this period oxygene air, mixed with twice its bulk of atmospheric, was administered for the space of one minute, four times a day. During the whole course of his disease, the patient had that tendency to sickness and vomiting, which the long abuse of fermented liquors produces. The modified air was found by the patient to relieve these symptoms; and by respiring it, he said he could prevent and remove nausea. From his observations I think ox. air more likely than any thing else to carry off violent affection of the stomach, arising from an overdose of digitalis. The difficulty of breathing was always relieved by his mixed air, though only for a short time. In less than a month, he by degrees came to respire for 15 minutes in a day. The swellings, however, increased, and there were evident signs of effusion in the thorax; so that the oxygene did not appear to render the absorbents more irritable. One day,
after

after walking for half an hour (which was an unusual exertion) the patient suddenly expired on entering his apartment.

The idea of administering oxygene air to persons affected with sea scurvy, is extremely obvious. But the frequent instances of sudden death, when scorbutic patients are brought into the open air, deserves serious attention. The principal doubt seems to be, whether it is muscular exertion, some sensation, or the free atmosphere, that proves fatal. After reading Dr. Trotter's late candid publication, I applied to the author for a solution of this difficulty; his instructive answer follows; and I own, that it appears to me to amount to a prohibition of the practice.



Spithead, March 13th, 1795.

SIR,

In answer to your query, whether the persons who died suddenly in scurvy on exposure to the air, had used much muscular exertion, I beg leave to inform you, that I do not think any preceding exercise of muscular motion had any share in producing this effect. The first case of the kind I ever saw, was from opening a port to windward; the air rushed in with considerable force, I was standing by the man, he had conversed with me with apparent ease, and seemed to feel no pain when he expired. I have seen others drop down immediately on coming above the hatchway, although they could walk below with tolerable agility: Some have died after being carried above, in a horizontal posture, both legs being so hardened and contracted

contracted that they could not walk ; and others have been saved by going immediately below. Might not all this be owing to the diminished temperature of the air, independent of its chemical qualities ? Scorbatic patients bear cold very ill, but sudden death happens often under similar circumstances in hot tropical countries, and I own this explanation not satisfactory.

I am afraid opportunities of trying the diluted oxygene in a ship, cannot be easily commanded. There is no medical board in the navy to countenance improvement. There is also so much room left for reformation in other respects for the benefit of health, that since I had the honor of attending the channel fleet, our great commander has been constantly ordering some beneficial regulations. From such active benevolence and authority, I have still much hope. Wishing you health to continue you valuable pursuits,

I am, Sir, &c.

T. TROTTER.



Having lately received information of a very ingenious application of air to surgery, I shall insert it here as the effect appears to depend on a residue of oxygene. —“ Mr Gimbernat, Surgeon, at Madrid, reflecting upon the action of atmospheric air, admitted into the joints, was led to suppose that its introduction into the scrotum would excite an inflammation of the adhesive kind in the parts that require to be united for the radical cure of the hydrocele ; in which case this might prove the easiest and most efficacious method of treating the disease.

Mr.

Mr. G. therefore passed through the scrotum of a patient, afflicted with hydrocele, a trocar much longer and thinner than that commonly employed in the operation for ascites ; taking great care to leave the testicle as much as possible behind, and at a distance from the instrument. He then withdrew the perforator, leaving the canula ; which being pierced with small holes in its whole circumference, allowed an issue of the water contained in the scrotum. When this was completely discharged, the operator stopped one of the orifices of the canula, and through the other blew into the scrotum a quantity of air from the lungs. This operation was repeated once or twice a day till the scrotum was reduced to almost its natural size ; for which purpose the canula was properly secured by a bandage in the scrotum.

When the parts had acquired so much adhesion as to contract round the canula, the instrument was removed, and the cavity it left was soon filled with new substance.

Mr. G. contrived this method 15 years ago ; and he has uniformly succeeded in a very considerable number of cases of hydrocele. A fortnight or three weeks has generally been sufficient for a radical and complete cure. The patient is never confined to his bed, but can walk about his room without inconvenience. Mr. Gimbernat thinks the great success of his method is owing to the small degree of inflammation excited by the expired air."

Mr. Townshend, in the 1st vol. of his *GUIDE* relates three cases in which the respiration of oxygen appeared highly beneficial. One is a case of hypochondriasis,

chondriasis, another of asthma, and a third of such disorder of the stomach, that eating "almost constantly produced vomiting;" in this case the patient "continued free from sickness as often as the oxygene "air in a diluted form was administered;" — (p. 277, 292, 398).

I had formerly been led to infer that "an atmosphere with a diminished proportion of oxygene, "would be in some cases a better soporific than any "we at present possess." I have since received confirmation of this opinion. A person in consumption, who for months had taken opium at night, slept perfectly well without opium when he came to respire hydrogen. His sleep he remarked to be more profound than usual. The air of his room being largely mixed with hydrogen, his servant, a very bad sleeper, declared that he "did not know what was come to "him, he slept so sound." This man necessarily inspired much hydrogen from attendance on his master. A physician has favoured me with the following memorandum of an observation on himself; which possibly may be referred to the same cause. He could not fix upon any other. "For several years I "have passed restless nights, and have seldom slept "longer than from half an hour to an hour at a time; "but on the night of the general illumination for the "victory of the first of June, I enjoyed a sound and "almost uninterrupted sleep; this I impute to my "having sat between four and five hours in a room "with about twenty candles burning, immediately "before I went to bed, and to having had the same "number burning as long in my bed-chamber; although the weather was warm, I felt a glow of
"heat

" heat on entering the chamber, with a strong smell of
 " the candles ; and as heat generally prevents my rest,
 " I was pleasantly disappointed by a more comfortable
 " sleep than I had had for fourteen years before. I
 " have experienced the same want of good and con-
 " tinued sleep since." Whether a diminished atmo-
 sphere produces a tendency to sleep or not, diluted
 hydrocarbonate (of which the properties can scarce be
 supposed to depend on privation of oxygene) undoubt-
 edly possesses this property. My experience amply
 confirms the preceding reports. In two consumptive
 patients, I am able to induce sleep almost at pleasure
 by this air. In a great majority of such cases, it is
 well known that the nights are exceedingly disturbed
 in spite of opium, freely administered. The soporific
 virtue of hydrocarbonate, seems however by no means
 to be confined to consumption.

I introduce here the following letter respecting
 consumption, from Mr. Darling, Pres. of the R.M. Soc.
 at Edinburgh. It did not come in time for insertion
 in its proper place. Mr. D. does not seem to have
 used hydrocarbonate air.

Edinburgh, Feb. 24th, 1795.

SIR,

The case to which I alluded in my letter was simply
 this.—A young lady labouring under every symptom
 of confirmed phthisis pulmonalis, and daily sinking
 under the disease, happened to be residing at the house
 of an eminent tar merchant to whom she was related.
 No remedy seeming in the least degree efficacious, it
 was proposed that she should walk in one of his ware-
 houses, where a large quantity of Plantation tar was
 M usually

usually kept. The first time she was introduced into it was on a Monday morning, when it was imagined, in consequence of the warehouse having been shut up since the Saturday afternoon, the air would be the most fully impregnated with effluvia. She walked a considerable time through the different ranges of barrels, and bore the experiment very well. This practice was persisted in several mornings with advantage: and finding the cough and other symptoms gradually decrease, she persevered till she was restored to perfect health.

Since I last wrote to you I have finished the account which I was then drawing up, of experiments with factitious airs in the cure of consumption, and read it to the medical society of this place. I have had about ten opportunities of trying their effects, but have been considerably disappointed, as I was not able to effect a permanent cure of any of them; but it must be observed, that in all of them the most distressing symptoms were evidently relieved — as the cough, night-sweats, diarrhoea, want of rest, fever, &c. and in one of them the hectic fever totally disappeared, and at present there only remains a cough, which is not very troublesome: nevertheless, I am much afraid that this immensely severe season may possibly bring on a relapse, but this must be guarded against as much as possible. My want of complete success I attribute in some measure to the imperfect state in which my apparatus was; or it may possibly have arisen from the remedies not having been applied with sufficient vigour, or perhaps from the disease in all the cases having made too great a progress before the administration of a reduced atmosphere.

W. C. DARLING.

I have

I have not displaced Mr. Darling's letter in the present edition. The same cause, viz. its arrival during the impression, obliges me to introduce the following interesting information from Dr. Pearson in this place.

Birmingham, Jan. 28th, 1796.

DEAR SIR,

As it may be twelve months before I publish *all* the facts which have come under my cognizance in favor of the use of æther-vapor, either alone or in combination with other substances, in phthifical cases; I wish in the mean time to make known to the medical world, an instance or two in confirmation of the good effects of this remedy, that it may get into other hands as soon as possible. I therefore send you the following cases and remarks, of which you will dispose in whatever way you chuse.

I am, with great regard,
Your's, &c.

W. PEARSON.

To Dr. Beddoes.

Elizabeth Vyse, aged 27, having been seized at the end of the autumn with cough, fever, and spitting of blood, applied to the hospital for relief, and came under my care last October. She informed me she had been subject to a cough for three winters. She had a quick and small pulse, flushed cheeks, dyspnœa, pain of the side, constant cough, attended with copious expectoration, and night-sweats. She was very feeble and

much emaciated. The hæmoptoe was soon removed by the medicines commonly prescribed in such cases ; but the other symptoms continued. I therefore ordered her, on the 12th of November, to breathe the vapour of vitriolic æther, impregnated with extract of cicuta, two or three times a day. On the 19th, when I saw her again, she informed me that she had obtained great relief from the æther-vapour, having much less tightness across the chest, and less pain of the side. She said she was somewhat giddy after every inhalation. December 3d, less fever, less cough, and considerably better in every respect. Has found more benefit, (to use her own words) from the æther application than from any thing else. December 10th, Cough and other complaints so slight, that she says she does not require any more medicines.

N. B. During the use of the æther-vapour, she took a decoction of the Peruvian bark and sarsaparilla, and pills composed of extract of cicuta and rhubarb.

In another case (a private patient) of a boy about fifteen years old, of a consumptive habit, a catarrh attended with fever of the hectic type, was removed in less than three weeks, by the application of the ætherial tincture of cicuta, in the form of vapour, to the internal surface of the lungs.



I have just met with Mr. Davidson's book on the pulmonary system. As I have not yet read a third part of it, I am not qualified to say any thing respecting the doctrine and practice therein laid down. I have only dipped into that part which treats of the
use

use of the cicuta in phthifical cases. I perceive he has fallen upon the idea of applying this narcotic to the internal surface of the lungs. To which of the two, him or myself, the thought first occurred, is a matter not worth dispute. I can only say that I have it recorded upon the books of our hospital, that I have been in the habit of prescribing to consumptive patients æther impregnated with cicuta (along with the extract made into pills), for as much as a twelve month past. Perhaps Mr. Davidson may have prescribed the vapour from decoctions of the same herb, as long. But, until now, I have been as entire a stranger to his practice as he no doubt has been to mine. It is of little consequence who first thought of the remedy; the point of most moment is, that both agree in the report of its good effects.

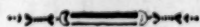
What induced me to prescribe it in this way, was the advantages which have frequently been obtained from it in scrophulous ulcers, when applied topically as well as internally. I do not, however, ascribe all, or even the greater part, of the good effects which I have experienced from this method to the cicuta; much, indeed the largest share of the benefit that has flowed from it, I attribute to the medium by which the narcotic particles of the cicuta were conveyed to the lungs; I mean the æther-vapour, which, when breathed alone, affords, in many pulmonic cases, very considerable relief. I wish Mr. Davidson, or any other gentleman, who is earnest in the business, would compare the effects of cicuta, when applied by means of the vapour of water, with those which it produces when applied along with the vapour of æther. Of the

former vehicle, I can only say that I think it objectionable on account of the heat which attends it. I do not forget Mr. Mudge's remedy for a catarrh; but the state of the lungs in catarrh and consumption must be allowed to be different. Moreover, I do not believe that water, even with the assistance of heat, can take up so many of the medicinal particles of the cicuta, as æther, which, besides, possesses (as I have before hinted) such peculiar properties, as are suited to induce a salutary change in the action of the vessels of the diseased part, properties which are altogether wanting in the steam from water.

P. S. In my last letter I forgot to mention that frequent agitation is necessary to promote the solution of the extract of cicuta in æther. Another way of expediting the solution is to triturate the extract (previously to its mixture with the æther) with a little salt of tartar or testaceous powder, and as much water as will give it the consistence of a syrup. Instead of the extract, I now employ the powder of the dried leaves, from which I obtain a much more saturated tincture.

Æther extracts the astringent principle from vegetable substances very abundantly. The tincture made with powdered galls is a very strong preparation. The vapour from æther thus saturated with the astringent principle, promises to be serviceable in some kinds and stages of phthisis, in which the state of the mucous glands of the bronchial tubes is analogous to that of the secreting vessels on the internal surfaces of the urethra and vagina, when these parts are affected with gleet and fluor albus. In these last the topical application

application of astringents is known to be of use ; and as there appears to be the same atonic condition of the secreting vessels on the internal surface of the lungs, in what is termed pituitous consumption, we have reason to believe that the same application will produce, in this case also, the like good effects.



In asthma it is extraordinary that oxygene, hydrogene, and hydrocarbonate, should have afforded relief. Dr. Carmichael has this reflection in one of his letters. It arose from the case of an asthmatic patient, whom one of the physicians to the Birmingham Dispensary, has lately much relieved by oxygene.— Dr. Ferriar (p. 80.) and Mr. Townshend, confirm the fact. It may be said that oxygene air prevents the paroxysm by exhausting excitability, as spirituous gargles cure an incipient inflammation of the throat ; and that unrespirable airs withhold stimulus ; but this seems by no means probable of hydrocarbonate ; and the truth is that we have not yet experience to establish those distinctions, which are requisite to the certain direction of the pneumatic practice.

In the inflammatory stage of catarrh, and all the gradations of disease which connect a common cold with pleurisy, I hope the exhibition of a lowered atmosphere will prove an effectual cure. In these cases I am at present inclined to prefer hydrogene or azotic air, because they can be so freely and frequently administered. In my letter to Dr. Darwin, I have described the effect of atmospheric lowered with one-eighth of hydrogene air, and respired for a quarter of an hour, in an inflammation of the chest. The acute pain entirely subsided while the patient was breathing this mixture,
and

and the febrile symptoms disappeared.—I have been eye witness of another fact of the same kind since. See *Confid.* part III. p. 91. — Mr. Townshend (p. 103) has a similar example. “ Mrs. Tovey, of Charles-
 “ Street, Tottenham - Court - Road, having lost one
 “ child” by the croup “ brought her only remain-
 “ ing boy to Dr. Thornton for his advice. He
 “ immediately made the child inhale azotic air with a
 “ proportion of common air; and the father and mo-
 “ ther were surprized when they observed that the
 “ hands which were before *parching hot*, now felt *cold*
 “ to the touch; the pulse was rendered twenty beats
 “ less in a minute; the child no longer coughed as
 “ through a brazen trumpet, the fever seemed smo-
 “ thered, and the formation of the fatal membrane
 “ was prevented.”— If a lowered atmosphere proves
 as serviceable in inflammatory catarrh as the analogy
 of these cases, reasonable conjecture and a few direct
 trials seem to promise, an apparatus for factitious
 airs will soon come to be considered as a necessary
 part of household furniture.

Different factitious airs enable us to change the
 constitution of the fluids and solids. By their opera-
 tion on the extensive surface of the lungs, they must
 also produce motions by association in distant parts of
 the system. On these principles (if we had no imme-
 diate experience) they might be concluded capable of
 great effects on the chemical and mechanical agency
 of the animal organization. I dare not enter fully
 into the contemplation of their powers: but there are
 two or three points on which it may be useful to
 touch.

Doubts

Doubts have been expressed whether the use of a modified atmosphere and especially, of unrespirable airs, could have any other than a momentary effect. This difficulty, a man who can see but a little way before him, will perceive. It has been cleared up by experiment; and I need not hesitate to affirm that the occasional respiration of modified air has a durable effect. But it is nevertheless true, that this important subject can never be sifted to the bottom, till we have the command of rooms filled with modified air. — Useful as diluted hydrocarbonate has proved, no man can say that it would not be more useful, if more diluted and respired with greater constancy. The same doubt extends to other airs.

It has been apprehended that the fine particles of manganese, suspended in oxygene, might injure the lungs, as in stone-cutters. But there is no analogy in the cases; engine-men, casters in brasse, and numerous other artificers, respire fine powder without detriment; and experience with the air itself discountenances apprehension. For we have now a number of instances in which oxygene from manganese was breathed for many weeks; and no such inconvenience has been felt.

Pulmonary tubercles are regarded by some as beyond the power of factitious airs to remove.* Tubercles however do not appear inconsistent with tolerable enjoyment of life; and there are many instances in
books

*This opinion, however must be retracted if the following curious information should prove just.

Extracts of letters from Dr. JENNER.

"I took the liberty, during our short interview, of offering an opinion respecting the origin (in some instances at least) of tubercles
in

books of medicine and surgery, of the removal of bodies equally formidable. By facts related in Dr. Ewart's pamphlet on cancer, and in Dr. J. Johnstone's letter, as well as by what I have myself seen, I am persuaded that the lymphatics were excited into vigorous action by carbonic acid air. In Mrs. A.'s case the surface of the ulcer became dry; and in that of Alford, "when the gas was most frequently renewed, the discharge was the most diminished." In an instance of cancer, not yet published, I am well informed that the swollen

and
in the lungs. A few days ago, I saw at a butcher's shop the lungs of a young heifer, which appeared to be diseased with tubercles. On cutting into some of these tumours, a *family* of hydatids immediately appeared. — Some of these tubercles, though similar in external appearance to those containing hydatids, had within them a brown fibrous kind of substance, which to the feel was a little gritty. In this case it is pretty clear, that the tubercle was a *manſion built* by the *hydatid*, and I am sorry to say this destructive little animal appeared to be unaffailable within its walls, as I could not perceive any branches of the trachea opening within them: but this may not be the case in the early stages of its structure. May not the infant tubercle described by Stark be an hydatid?



"The fact of the hydatids forming tubercles in the cow's lungs was very clearly ascertained. I made a preparation of the parts. — Pray make what extracts you please from my letter, if you think I have expressed myself intelligibly. Many of Dr. Stark's observations on tubercles tend to strengthen my idea of their origin, particularly the following. "No blood vessels are to be seen upon them, even when examined by a microscope, after injecting the lungs from the pulmonary artery and vein." (Medical Communications I. page 390.) If, as I suppose, they are extraneous bodies, they are of course no more capable of receiving injections, than worms that adhere to the intestines. Stark describes the tubercle, as being hard and compact before it arrives to any considerable size. — If I recollect right, that species of hydatid, which pervades the cellular membrane of the hog is solid or nearly so. It is singular enough that hydatids should be more common among those animals which live in a state of nature than among the human species. — Hares, rabbits, cows, and hogs are infected with them perpetually; — the hog, indeed, can scarcely be said to be in a state of nature here. Among quadrupeds, I do not see that the constitution is affected by them; the animals thrive and grow fat in an equal degree with those which are free from them, even though they occasion suppurations among the viscera. — In the liver of the cow that produced the hydatids from the lungs, were several distinct bags of well formed pus, yet the animal was very fat and had no marks of disease before it was slaughtered.

E. JENNER,

Berkeley, Jan. 29, 1796.

and indurated glands have been reduced by carbonic acid air to their natural size and softness. Hence I conclude that the salutary operation of this air in part consists in its action on the lymphatic system; and it can hardly be doubted that there is a degree of absorbent operation equal to the removal of tubercles.— Whether hydrocarbonate possesses this property, the trials now making on cancers are likely to decide.— I wish the respiration of unrespirable airs were tried in encysted dropsy; in one case of which I fully tried oxygene without benefit.

If a species of opium, capable of lulling the excruciating pain of cancer for weeks or months, had been discovered, it would doubtless be received with avidity by the members of the medical profession, and with benedictions by the diseased. But because it is uncertain whether a compleat and permanent cure can be effected by the application of air, this treatment is not only neglected, but resisted; yet no pretence is made to substitute any thing more efficacious: no natural cure or mitigation is looked for; no injury is dreaded from the new method; and the authority on which it is said to afford at least long-continued ease, is neither questioned nor questionable. For such conduct, language wants a term sufficiently opprobrious, for it implies whatever is contemptible and odious in sloth, in ignorance, in narrowness of mind and hardness of heart. Here I invite my readers to reflect and to hold their opinions at all times ready for delivery; for although this great crime against humanity is not punishable by law, it may be prevented by the censure of an enlightened public.

PART II.

DESCRIPTION
OF A
PNEUMATIC APPARATUS,
WITH
DIRECTIONS
FOR PROCURING
THE FACTITIOUS AIRS.

By JAMES WATT, ENGINEER.

MR. WATT'S advertisement to an edition of his
Description, published separately.

SINCE the first publication of this Description, experience has suggested some improvements in the mode of constructing and of using the Apparatus, which in the present state of Pneumatic Medicine, it would be improper to delay communicating to the Public. Every hint, however trifling in itself, now attention is awake, may lead to useful discoveries.

The Author has also availed himself of this opportunity to methodize and elucidate his description in a manner which the former hasty publication would not admit of. One of the original plates has been rejected, and another, representing the improved use of the Fire-Tubes, has been inserted in its place. Conceiving the Apparatus may fall into the hands of persons who have not been accustomed to chemical

chemical experiments, clearness has been aimed at, even at the hazard of prolixity. Though the Author wishes to shun the imputation of neologism, yet to avoid circumlocutions, he has found himself obliged to form some new words, such as the Martial Zincic, and Carbonic Inflammable Airs, which latter he has also called Hydro Carbonate.—He has indifferently made use of the terms of the old and new Chemical Nomenclature, wishing merely to be understood, and not intending to enter into discussions upon theories in a treatise, the objects of which are facts.

The purchasers of the first edition, it is hoped, will not deem any apology necessary. It contained all the Author then thought worthy the notice of the Public, as this contains all he now deems essential to the right use of the Apparatus, which probably, from the progressive advancement of Pneumatic Chemistry, will soon receive great additions.

At the time of the former publication, few professional men having considered the subject, the Author ventured to give his opinion in some letters to Dr. Beddoes, on the airs which he thought the most likely to be of use in diseases of the lungs, and he esteemed it a duty to relate the few physiological observations he had made in the course of his chemical experiments to produce the airs; but he now thinks it would be improper to swell his pamphlet by a republication of those letters, as the subject is taken up by persons who are better able to judge in such matters. For what has yet been done in the application of the air to medicinal purposes, the Reader is referred to the publications of Dr. Beddoes and Dr. Ewart upon this subject.

Several

Several of the apparatus are now in the hands of able practitioners, and the Public at large is apprized of the importance of the practice, and will no doubt give it a fair trial. It is honorable to the present improved state of science, and it is honorable to the faculty in particular, that the application of Pneumatic Chemistry to medicine far from meeting with that persecution which has generally in every age followed new opinions, has obtained the well wishes and liberal support even of those who have doubts of its efficacy, but who are no less desirous of having those doubts cleared up by actual experiment.

HEATHFIELD, Jan. 1795.

DESCRIPTION

DESCRIPTION
OF A
PNEUMATIC APPARATUS.



THE apparatus may, for the facility of description, be divided into four parts, the uses of which are essentially different. First, an ALEMBIC, or POT, A, *see plate 1, fig. 1*, or in lieu of it, a FIRE-TUBE, a, *(see plate 1, fig. 3, and plate 3, fig. 1, 2, and 3)* intended to contain the material or substance to be exposed to the action of the heat, with a *Water-pipe* D C, adjusted to its capital, for the purpose of admitting water to assist the generation or expulsion of the factitious air.—Secondly, A REFRIGERATORY G (*plate 1, fig. 1*) serving to cool and wash the airs, which are conveyed thither by the *Conducting-pipe* F, connected with the Capital of the Alembic or Fire-tube.—Thirdly, an HYDRAULIC BELLOWS H J, to receive and measure the air as it comes cooled from the Refrigeratory through the *Communicating-pipe* P.—And, Fourthly, an AIR-HOLDER Y, *plate 3, fig. 1 and 2*, into which the Hydraulic Bellows discharge the factitious air by means of the *Transfer-pipe* g, and in which it is afterwards preserved, and may be removed from one place to another.

In lieu of this latter vessel, in cases where the patient is at hand, the air may be immediately transferred from the Hydraulic Bellows through the *Discharging-pipe* Q, into oiled silk or linen bags, or such other vessels as shall be thought convenient for mixing it with the proper proportion

portion of common air, and also for the patient to inhale from.

1. The ALEMBIC and FIRE-TUBE. *The Alembic A*, see plate 2, fig. 4. is made of soft cast iron, about half an inch in thickness, and six inches in diameter in its widest part or *bilge*. It has a Capital B, of the same metal, the lower part of which is made conical and ground into its mouth, so that the joint may be made tight with a small quantity of cement. Through the middle of the upper part of the Capital passes the *Water-pipe D C*, which reaches to within a small distance of the bottom of the Alembic; at the top of it is a cup D, to contain water, in the centre of which a wire E, is placed, extending within the Water-pipe to C, where it terminates in an acute cone, accurately fitted to the lower opening of the Pipe as shewn in plate 2, fig. 5. The upper end of this wire has a button affixed to it to turn by hand, and the part immediately under it is formed into a screw, which works in a bridge fixed across the cup, so that by turning the screw, you may either raise or depress the wire, and thereby regulate the quantity of water to be admitted, or entirely exclude it. The joints of the Water-pipe at C, and at the top of the Capital, are made conical for the greater facility of rendering them tight, by anointing them with a small quantity of the china clay or other lute hereafter described; which is likewise to be applied to the joint where the *Conducting-pipe F*, enters the side branch of the Capital.

The Alembic above described, may be used for producing any of the artificial airs, and seems the best vessel for making that from Zinc. At the time this description was first published, it was thought that it would have

N

proved

proved the most convenient for all purposes, but experience has since shewn the contrary.

The *Fire-tube*, such as represented in plate 1, fig. 3, when of equal contents with the Alembic, exposes a greater surface to the action of the fire, and exposes the substances contained in it better to the operation of the steam produced from the water, and thus yields the airs more readily and with less waste of fuel. It is therefore preferable for preparing air from charcoal, iron turnings, chalk, &c. and answers very well for the Oxygene air from Manganese.

The main tube *a*, plate 3, fig. 1, 2, and 3, is of cast iron, open at both ends; a kneed pipe, called an *End piece*, *b*, is afterwards fitted to one extremity, and receives into its perpendicular part a water pipe, such as that described for the Alembic. To the opposite extremity of the tube, another similar end-piece, *c*, is fitted, the side branch of which is placed horizontally to receive the Conducting-pipe *F*, which conveys the air to the refrigeratory. The joints are made conical, ground into one another, and made tight with lute in the same manner as those of the Alembic.

The cast iron, of which the Alembics and Fire-tubes, with their Capitals and End-pieces are made, is certainly liable to some objections; but it has been preferred as being the only *substance*, yet tried, which can bear the vicissitudes of heating and cooling, and the application of water, when red hot, without much injury, and the only *metal*, not too costly, the fumes or abrasions of which produced by the action of the water and airs might not have deleterious effects. For this latter reason no copper is employed in any part of the apparatus.

The

The *Conducting-pipe F*, which conveys the air from the Alembic or Fire-tube to the Refrigeratory, is made of forged-iron, about $1\frac{1}{4}$ inch in diameter, tapering to the ends to fit better. The length is from three to six feet, as suits the conveniency of the operator. To ascertain the nature of the air, a small hole, stopped with an iron plug, is made near the refrigeratory end; by taking out the plugs and holding a lighted candle to the hole, you may in some degree determine when any particular kind of air begins to come over. It would make the apparatus still more perfect, if a bent tube were fitted to the Conducting-pipe near this place, and the air was received, according to Dr. Priestley's method, in jars through water; but care must be taken that the pillar of water through which the air passes, be not greater than that in the Refrigeratory. The quality of the air might then be more accurately determined by the usual tests.

2. The REFRIGERATORY. This vessel is made in three different ways, according to the nature of the airs to be cooled by it.

The *Circulating Refrigeratory G*, plate 1, fig. 1, is used for airs which require washing as well as cooling, to make them deposit any extraneous matters which they would otherwise carry over with them. It consists of two parts, as shewn in the plans and sections, plate 2, fig. 2 and 3, the upper part is represented in the inverted position in which it is to be placed within the other. In fig. 2, the outer vessel G is represented, furnished at one side with a funnel and pipe R, for conveying cold water to the bottom; on the opposite side are two circular apertures, with short pipes and corks fitted to them;

the upper serves to let off the heated water, and the lower to empty the vessel. *Fig. 3*, is a plan and section of the inner vessel S; it is open at bottom, but its cover is convex, and has a spiral channel winding along the underside, which being likewise open below, the air coming from the Alembic or Fire-tube, by the pipe N, at the circumference, passes through the whole of it in constant contact with the water of the Refrigeratory, until it arrives at the pipe O, fixed near the centre, which delivers it to the Hydraulic Bellows, by means of the Communicating-pipe P. In this long circuit it is both cooled, and in a considerable degree washed and freed from any matters from which water has an attraction. In the centre of the inner or spiral vessel, is a short pipe open at both ends, reaching to the lower edge of the plates that form the spiral, and intended to serve as a passage for the hot water to rise through by its lesser specific gravity, when cold water is introduced below by means of the funnel R, and also for the stem of the Agitator to work in. The hot water is then suffered to run off through the upper pipe of the outer vessel, and thus by a frequent renewal, the water in the Refrigeratory is kept both cool and unsaturated. A notch is made in the inner vessel at T, to receive the pipe R, and prevent its impeding the rim of that vessel from resting upon the bottom of the other; in which position, when in use, it is to be kept steady by laying lead weights upon it.

When it is wanted to free the airs more perfectly from any acid taint, the *Agitator* or *Stirrer* is to be employed. This instrument is made of wood, in form of an inverted T, with a small winch to turn it by at the upper end of the axis or stem. The lower end of the axis or stem fits into a small cup at the bottom of the Refrigeratory,
and

and the other passes through the short pipe in the centre of the inner vessel, and turns in a socket affixed to the pipe O. The agitator being gently turned round by the winch, puts the whole water in motion ; thus continually exposing fresh surfaces to the air in its passage to the bellows, and when the water is mixed with the powder of quick lime it serves to keep it suspended.

Tin plates japanned have been found to be the best material for making both the inner and outer vessel.

The *Close Refrigeratory* may be used for airs which are liable to be absorbed by the contact of water, such as fixed or carbonic acid air. It consists of a cylindrical vessel, with a close diaphragm fixed a few inches from its bottom, as represented at X, *plate 3, fig. 1 and 2*. The conducting-pipe from the alembic opens into the space below the diaphragm, where the steam it brings with it is condensed, and the air cooled by means of cold water poured into the upper part of the vessel upon the diaphragm, which is to be renewed as it warms, by letting off the heated water through a pipe *h* made for that purpose, and pouring on fresh. By this means the air is compleatly cooled, without coming in contact with the water, and is afterwards conveyed to the hydraulic bellows through the communicating pipe P. An aperture with a short pipe *i* is left in the lower or close part of the vessel, to let off the condensed steam, and inspect the quality of the air, if at any time need be.

Should however the circulating refrigeratory be preferred for the sake of washing the air, and freeing it from some of the calcareous earth, or other extraneous matter it brings over with it, the loss of air by the ab-

sorption of the water will not be very considerable, for the water soon becomes saturated, and as it grows warm yields back great part of the air in a purer form.

The *Pipe Refrigeratory* is the most simple of all, but can only be used when the air produced brings no aqueous vapours over with it, and requires no washing. Its use is therefore confined to the cooling of *dry* airs, such as that produced from charcoal burning in the open air. It consists of a plain pipe *n* passing longitudinally through a trough *m* filled with water, such as that delineated *plate 3, fig. 5*, and connecting the hydraulic bellows immediately with the furnace or pot *l*, in which the charcoal is burning.

By connecting this pipe with any close vessel, to collect the condensed water, it may be made to answer all the purposes of the close refrigeratory.

3. The HYDRAULIC BELLOWS. An outside view of this vessel is given in H J, *plate 1, fig. 1*, and *plate 3, fig. 1*, and an inside view in *plate 2, fig. 1*. It consists of an outer or fixed vessel H, and an inner or moveable vessel J, which moves easily up and down within the other, and is suspended by a cord passing over two pulleys K K, and sustaining a counterpoise L. To avoid the incumbrance of a great weight of water, the outer vessel H is made double, so that only an interspace of about half an inch is left between its two cylinders for the vessel J to move up and down in, and this must be filled with water as high as the pricked line in *plate 2, fig. 1*. The cup or rim W is to prevent the water from overflowing when the inner vessel is pressed forcibly down. The factitious air enters from the refrigeratory
by

by the communicating pipe P, and passes along the perpendicular pipe V into the cavity of the vessel J, which continues rising until it is full, when the framing M will permit it to go no higher. The air is then expelled into the air-holder or bag, through the *discharging-pipe* Q, by lifting up the counterpoise L, and allowing the inner vessel to descend by its own weight.

This vessel is also made of tin plate japaneed. Some slight variations have been made in the execution of those for sale since the two first plates were engraved, but none of sufficient importance to merit particular mention.

4. The AIR HOLDER. The structure of this vessel is shewn at Y, *plate 3, fig. 1 and 2*. It is made of tin-plate, japanned both inside and outside, and is close at both ends; but for the conveniency of japanning the inside, it is made in two halves, which are joined together in the middle of the vessel, by a cement composed of bees'-wax and one fourth of its weight of rosin, applied hot. By warming the joint before a fire, the vessel may at any time be taken asunder and cleaned. Two short pipes, U and Z, proceed from the side of the vessel, near its top and bottom, and another pipe, *t*, passes through the middle of the top or cover, to which it is well soldered and reaches to within half an inch of the bottom.

When the lower pipe Z is corked, the upper one U remaining open, the vessel may be filled with water through the central pipe *t*, to which, for the conveniency of pouring, a funnel *k* is fitted; by withdrawing the cork of the pipe Z, the water may again be discharged, the external air which enters through the pipe U supplying

supplying its place. So that if when it is filled with water, a short pipe *g*, called the *Transfer-pipe*, be inserted and cemented into the upper pipe *U* of the air-holder, and into the discharging-pipe *Q* of the hydraulic-bellows, and if the lower pipe *Z* of the air holder be then opened and the inner cylinder of the bellows be allowed to descend, by lifting the counterpoise, it is obvious that the factitious air contained in it will be transferred into the air-holder. The pipes *Z* and *t* are to be well corked as soon as the air holder is filled, but there should always be left an inch of water at the bottom of it, to impede still more all communication with the external air; as soon as it is disjointed from the rest of the apparatus, the pipe *U* should likewise be carefully corked.

Corks are preferred to cocks for shutting these openings, both because when good, and well fitted, they are perfectly air tight, and because common cocks are made of a metal, the rust of which is very poisonous, being a composition of copper, lead, tin, arsenic, and antimony, or whatever other metals the ores may happen to contain.

OILED SILK BAGS, as it has been already mentioned are convenient for removing factitious air from one room to another, and for the patient to inhale from. They may be made in the form of a common sack, tapering at one end like a bottle, and having a conical wooden faucet fixed in the mouth, with the smaller end outwards, into which a spigot is to be inserted.

To free oiled silk from its disagreeable smell, cut it into pieces of the size wanted for the bags, and provide a smooth table somewhat larger than the pieces of silk and a flat board the same size as the table. Take *char-*
coal

coal fresh burnt in an open fire until it is free from smoke extinguish it by shutting it up in a clean close vessel, and reduce it to powder. Sift this powder over the table to the thickness of a quarter of an inch or more, spread a piece of your silk upon it, and sift upon that again another layer of your charcoal dust, and thus proceed alternating the layers of silk and charcoal, until the whole of your silk is deposited; then lay your moveable board upon the top of all, and leave the whole undisturbed for four or five days. If upon removing the charcoal dust, the silk has not lost its smell entirely, repeat the process. The charcoal dust is to be swept off the silk, and the silk to be washed upon a table with a wet sponge until it is clean. The bags must then be carefully sewed up, and the seams anointed with japaner's gold size, taking care to use that kind which does not become brittle when dry. This is used in preference of drying oil, because it has not so bad a smell. Green oiled silk should be avoided, as it is stained by means of verdigris, which rots it; the yellowish silk is the best.

Dr. Beddoes says he observed the thicker oiled silk to answer better than the thinner kind; that probably oiled lined will be found to answer; that the bags, when out of use, should be hung up by a string tied to the faucet, and that they should be as little creased as possible. To this may be added, that the best way of emptying them of all the air they contain, is to lay them flat upon a table, and to pass the hand, or a round paper ruler, gently over them.

It is necessary to observe here, that although oiled silk be the best substance known for making the bags of, it is very imperfectly air-tight; and although charcoal
dust

dust deprives it of smell for the time, yet as it can only attract the odoriferous particles from the surface, it re-acquires some smell by keeping, but by no means equal to what it had at first. — The desideratum is some thin flexible substance, whose pores can be more perfectly closed than those of silk, and a varnish without smell, or some kind of light bellows, not of the hydraulic kind.

FURNACE. Many persons to whom this apparatus will be useful, being unprovided with a convenient furnace, I have endeavoured to make one of such a construction as to adapt it to the uses both of the alembic and fire-tube, which has necessitated some slight variations from the one represented *plate 1, fig. 1*, but which are all shewn in *plate 3, fig. 1, 2, 3*.

The ash-pit and furnace are both made of one piece, of a cylindrical form. The furnace part is lined with fire-bricks, is 14 inches diameter within, and 18 inches over all; the depth to the grate is 11 inches, and that of the ash-pit about 7. Two circular holes, of $4\frac{1}{2}$ inches diameter, are made in two opposite sides of the furnace to admit the fire-tube, which when the alembic is used are to be stopped with plugs of fire-clay. Two cast iron rings, *rr*, are sent with the fire-tubes, which when they are used fit upon the ends, and serve to shut up the circular holes of the furnace as accurately as can be done. The covers drawn in *plate 1* are not found to be necessary.

A smaller furnace has likewise been made for a smaller apparatus, 9 inches diameter within the brick lining, and 9 inches deep to the grate. The fire-tubes for this are only 3 inches diameter without.

Those

Those who wish occasionally to convert these furnaces into distilling furnaces, may have a fire-door *d* fitted to one of the side holes, a chimney-pipe *p* to the other, and a cast iron pot for containing sand, adapted to the mouth of the furnace; *See plate 3, fig. 4*; but none of these are necessary for the particular application of it to this apparatus.

Both furnaces have a door *f* to shut up the ash-pit, and at one side a sliding damper *s*, to regulate the quantity of air admitted, for when the corks are good, and the gates clear from ashes, the fire might become too strong if the fire door were to be left open. No chimney is used in the operations for producing airs, because a sufficient and a better regulated heat is produced without one; a flat plate, however, is useful to cover the furnace when the operation is over, which when the door of the ash-pit and the air-hole are shut, will soon extinguish the fire.

DIMENSIONS of the APPARATUS. The apparatus is made of *two sizes*. The hydraulic bellows of the *larger*, is 12 inches diameter, and the moveable vessel rises about 15 inches, so that each inch in height contains 113 cubic inches, and the whole bellows 1695 cubic inches, or rather less than a cubic foot. The bellows of the *smaller* apparatus are about one third of the contents of the larger, being $8\frac{1}{2}$ inches diameter, and rising 13 inches, so that each inch in height contains 57 cubic inches, and the whole of the bellows consequently 570, or about one third of a cubic foot.

The Air-holders are also made of two sizes, the larger containing a cubic foot, and the smaller half a cubic foot ;



foot; which dimensions have been fixed upon as convenient for carriage when filled with air, and capable of being lifted by one person when full of water, which would not be the case if the contents were more than a cubic foot. The small air-holders will, on account of their reduced contents, be chiefly useful for conveying *Fixed air*, which should be sent out in such quantities only as are likely to be used at once. For if water be poured into an air-holder to expel part of the fixed air, and the air-holder be afterwards corked up and laid by, great part of the remaining air will be absorbed by the water.

The large Fire-tubes are three inches in diameter within, and have 14 inches in length exposed to the action of the fire; the Alembic, when filled to the neck or cylindrical part, is about equal to them in its contents. The small fire-tubes are $2\frac{1}{4}$ inches diameter within, and have 9 inches exposed to the action of the fire, consequently the contents of the larger tubes is to that of the smaller as 54 to 126, but the quantities of air which will be produced from them respectively, will not follow that ratio, because the heat will be more readily communicated to the centre of the matter contained in the small tubes, than it will to that of the large ones. Their respective actual performances have not been compared.

The larger apparatus is particularly useful where considerable quantities of air are required, especially for carbonic acid air from chalk or marble, or oxygene air from manganese, where it is of some consequence to be able to operate upon a large quantity of materials at once.

For

For the use of private individuals, or for experiments, the smaller apparatus will be found large enough; but if any quantity of air is wanted to be produced, and the operator is not too much confined for room, it will be adviseable to combine the larger bellows and refrigeratory with the smaller furnace, to avoid the trouble of too frequently emptying the bellows, and to enable the operator to retain a reserve of air within them.

STOOLS. Before attempting to use the apparatus, stools should be provided for the different parts to stand upon. They are best made with round tops, and for the *large apparatus* should be 16 inches diameter, and about $1\frac{1}{2}$ inch thick, of elm or oak board, with three plain feet. The following heights are taken from the stools to the ground.

Stool for the Refrigeratory	-	18 inches.
Ditto Hydraulic bellows	-	24
Ditto Air-holder, allowing an inch for the thickness of the tub it stands in.	}	$8\frac{1}{2}$
-		

When the fire tubes are used, the same stools as above will serve, only an additional one of $14\frac{1}{2}$ inches high must be provided to place the furnace upon. This may be made of iron, but the heat is not there sufficient to burn it, even if of wood.

The *small apparatus* is adapted solely to the use of fire-tubes, and the following stools of one foot diameter will be necessary in using it :

Stool for the furnace to stand upon	12 inches high.
Ditto for Refrigeratory	- - 17 ditto.
	Ditto

Ditto for Hydraulic bellows - 23 inches.

Ditto for *large* Air-holder (allow-
 ing one inch for the thickness
 of the tub) - - - - - } 7 ditto

These stools are required to be so high on account of the air-holder, which would not otherwise have room to empty its water into a moderate sized tub. The elevation of the apparatus will be found a convenience to the operator.

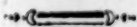
If the smaller furnace be adapted to the larger apparatus, the heights of the stools will be as above, excepting that of the refrigeratory, which must be reduced to 16 inches; but in that case the stools of course must be of the diameter mentioned for the larger apparatus.

A stool that can be raised and depressed at pleasure, will be found convenient for placing the apparatus upon that is intended to receive air under water See p. 187.

GENERAL DIRECTIONS

FOR

THE USE OF THE APPARATUS.



AS it has been already mentioned that the fire-tubes are more convenient for general purposes than the alembics, it may be proper to describe their use first.

FIRE-TUBES. Thrust the plug sent with the apparatus into one end of the tube, and holding it perpendicularly resting upon that end, put into it what quantity you please of the material to be acted upon, taking care that the whole lie within the wide part. Lay the tube upon its side, take out the plug, anoint the end piece, which corresponds to the conducting-pipe, with the *Fire-lute* hereafter described, and (having first put one of the cast iron rings upon that end of the tube) insert it into the tube, turn it round a little, pressing it in at the same time, and then give it a gentle blow with a piece of wood, to force out the superfluous lute. Pass the fire-tube thro' the two holes made in the furnace to receive it, and put the remaining iron ring upon the other end of it. so as fill the hole on that side. Anoint the conical end of the conducting-pipe with lute, and thrust it into the end piece above-mentioned, letting it incline about an inch towards the refrigeratory, into the receiving-pipe N of which the other end must be inserted, being previously anointed with the *Cold Lute* hereafter described. Join the pipe G of the refrigeratory with the communicating pipe P of the hydraulic bellows, using the above lute for the joints. These being adjusted, anoint the other
end

end piece of the fire-tube with fire-lute, and fix it in its place, so that the water-pipe C D may be perpendicular. Lute also the joint of the water pipe, and fix it in its place. Fill the cup D with water, having first screwed down the wire E, that no water can pass into the fire-tube.

As water is not absolutely essential for the production of oxygene from manganese, you may in that process insert the iron plug, properly anointed with fire lute, into the tube, in lieu of the end piece above-mentioned.

You may now proceed to light the fire.* — Lay the lead weights upon the inner vessel of the refrigeratory, and fill it with water, as also the outer vessel of the hydraulic bellows up to the dotted line shewn in plate 2, fig. 1, but no higher, otherwise the water will run down the perpendicular pipe V. Press down the inner vessel J of the bellows to empty it of air, cork the discharging pipe Q, and hang on the balance weight L†.

As soon as the lute of the joints which are exposed to the action of the fire is dry and hot, apply to them some of the *Fat-Lute* hereafter described, and to prevent its running off, strew some dry-slacked lime over them. This fat-lute will prevent the joints from cracking, but care must be taken that none of it get into the inside of the fire-tube, as it would give a bad smell to the air.

* The directions here given are for the *Circulating Refrigeratory*, as being most commonly used; those for the *Close Refrigeratory* will be found under the article *Fixed Air*; and those for the *Pipe Refrigeratory* under *Phlogisticated Air*.

† The Air-holder may either be fixed on now, or hereafter, as described page 202.

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In cases where water is necessary for the production of the factitious air, as soon as the fire-tube is become red hot, unscrew the wire E, so as to admit a little water into it. The air will immediately pass through the conducting-pipe to the refrigeratory, and gliding along its spiral in contact with the water, will arrive at the bellows through the pipe P, washed and cooled. It is best to admit no more water into the fire-tube than enters into the composition of the airs, or is necessary for their expulsion, as you will thus obtain them apparently more condensed and powerful than when a superfluous quantity of water is admitted. The latter circumstance may be known by the pipe at N becoming too hot for the finger to bear.

Care should be taken to renew the water from time to time in the refrigeratory, and to keep the agitator constantly in a gentle motion if the production of the air is quick, but in cases where the production of air is not very rapid, it will be sufficiently washed and cooled without using the agitator. In processes where you wish the fixed air to be absorbed that may accompany the other factitious airs, it will be found necessary to fill the refrigeratory with lime water, or still better, to add powdered quick lime to the water contained in it. The inner vessel J of the hydraulic bellows will rise gradually as the factitious air enters, but when it is full, or nearly so, it is proper to transfer the air into the air-holder, which for that purpose must be placed upon a small stool in a shallow tub, and filled with water through the central pipe, in the manner already directed. Connect the air holder to the bellows by means of the transfer-pipe g, and lute the joints. Then take out the cork from the lower pipe Z, and the counterpoise of the bellows being

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being lifted up, the factitious air will pass into the air-holder, and the water be emptied into the tub. The issuing of the water may be rendered slower at pleasure, by holding the end of the cork against the opening of Z, which should be re-corked as soon as the air-holder is full, or the bellows completely emptied of air. The air-holder is then to be removed, and all the pipes to be well corked.

It should be kept in a cool place until the air is wanted, which may be transferred into one of the oiled bags as follows:—Fix the faucet, or mouth piece of the bag, lapped round with some wet linen rag, tied with a thread, into the inner pipe U of the air-holder, having previously squeezed all the common air out of the bag, in the manner directed page 193. If you want a quart, gallon, or other measure of factitious air, pour that quantity of water into the air holder, by means of the funnel & through the central pipe (which reaching within half an inch of the bottom, precludes the air from escaping, and exactly that measure of the inclosed air will issue out into the bag.* Then recork your air-holder, if not exhausted of air, apply at the same time your thumb on the outside of the bag, and pressing it against the inner orifice of the faucet, to prevent the exit of the air until you can insert the spigot, which should be previously wetted.

The quantity of atmospheric air wanted to be mixed with the factitious air, should be thrown into these bags by

*It has been already remarked, that the factitious air may be transferred immediately from the hydraulic bellows into the bags, by inserting the faucet, lapped round with a linen rag, into the discharging pipe Q, and suffering the inner vessel of the bellows to descend, until as much air as is required enters the bag, which you may know by marking the quantity of the descent of the bellows.

by a pair of common bellows, the nozzle of which will admit the faucet of the bag, or by an hydraulic bellows appropriated to that purpose, and not by that which receives and measures the factitious airs, which will in general be otherwise employed. The smaller sized bellows will be found sufficiently large for this purpose. When both the airs are included in the bag, it should be repeatedly turned up and down, in order that they may be perfectly mixed.

Some gentlemen prefer an hydraulic bellows made to hold three or four cubic feet of air, to the bags for breathing out of; but such an apparatus cannot fail of being cumbersome in many cases, and in all will be troublesome to remove, especially when filled with air.

Should the factitious air contained in the air-holder, require to be more thoroughly freed from fixed air or acid fumes, than has been done before; it may be effected by putting some dry slacked lime down the central pipe, pouring a small quantity of water upon it, and agitating the vessel briskly; but so much atmospheric air will enter on uncorking the pipe as there was fixed air absorbed.

AIR MAGAZINE. Some persons may wish to preserve in readiness larger quantities of air than can conveniently be kept in air-holders. The most readily constructed vessel to answer this purpose, would be a common cask or hoghead, open below, and suspended over another larger cask, filled with water, by a cord going over pulleys, and a counterpoise, in the same manner as the hydraulic bellows. The air might be admitted and taken out by means of a flexible pipe and a cock attached to and communicating with the upper end of

the suspended cask ; the latter vessel being rendered air-tight by shaving it smooth both inside and out, and filling up its pores with bees wax, applied when the cask has been made very hot by a fire of straw or shavings. The wax should continue to be applied until the pores will receive no more, and then the superfluity be wiped off. Oiled paint would give a poisonous impregnation to the water, and a mixture of rosin gives a bad smell.

For inflammable and dephlogisticated airs, the water over which they are kept may be impregnated with lime, which will prevent the putrefaction of the water, and will also serve to absorb the fixed air. Fixed air itself cannot long be preserved in this way, even when there is no lime in the water. Something of the same nature with the air-holder, seems most proper for this air, as the small quantity of water included with the air, would soon be saturated ; and for the same reason, the air-holder applied to this use, should not be large, otherwise the water employed to expel part of the air, might absorb the remainder.

ALEMBIC, or FIRE-POT. When you have put into this vessel the proper quantity of materials to produce the facitious air, force a piece of iron down through them to make way for the water-pipe, then lute the joint of the capital B, and fix it in its place. Lute and put in the lower part of the water-pipe C ; set the pot on its pedestal in the middle of the furnace, and connect together the remaining parts of the apparatus, as has been described when the fire-tubes are used.

In letting in the water and regulating the whole of the apparatus, proceed exactly in the manner related above.

LUTES,

LUTES, or CEMENTS. *Fire-lute.* To join together the joints exposed to the action of the fire, viz. the end pieces and water-pipe with the fire-tube, the capial with the alembic and the conducting-pipe to either of them, the proper lute is the Cornish porcelaine clay, or slacked and finely sifted lime, mixed to the thickness of paint, with a solution of two ounces of borax in a pint of hot water.

Cold lute. For the other joints, a paste of dough made of about equal parts of wheat flour and porcelaine clay, or common whiting, which, for greater security, may when the joint is luted, be wrapped round with a rag. A slip of oiled silk does very well without any lute.

Fat lute. Is made of finely sifted slacked lime and drying linseed oil, wrought into a pretty stiff paste, and applied to the hot joints with a small trowel.

Fuel. The proper fuel is good coaks or cinders of pit coal, which ought not to be of the heavy sort, nor too small, as in either case you would have a dull fire. The charcoal of wood would answer very well, but it is expensive, and the consumption would be considerable. A fire of pit-coal not coaked, is irregular and unmanageable. Care must be taken to have your coaks well dried; and the first time you use the furnace, you will do well before you operate, to warm and dry it with a fire of coaks, to chase off any moisture the bricks may have imbibed, otherwise your fire will be long in lighting.

GENERAL CAUTIONS.



EACH time before you use the apparatus, it should be washed with cold water, to free it from any effluvia it may retain from the last operation. The same fire-tube or pot ought not to be used for producing different airs; and for this reason, it will be proper to keep one appropriated to the making of each. Indeed, should ever an establishment be formed for making large quantities of the different kinds of air, it will be certainly advisable to have an entire apparatus appropriated to the making of each kind.

No bituminous or oily substances should be put into the pots or tubes, for the making of inflammable airs, or any other purpose. Nor should any substance likely to yield any of the mineral acids, be used in the apparatus, as the fumes would destroy both the conducting-pipe and the refrigeratory. The same objections lie against the volatile alkali, and to putting any alkali into the water of the refrigeratory; but as far as has been observed, lime water does not hurt the varnish.

The process for obtaining the inflammable airs, should not be conducted by candle-light, otherwise the approach of the candle to the stream of air may occasion dangerous explosions. For the same reason, when any patient is inhaling this air by candle-light, the candle should be kept as distant as possible.

In all cases, wherein the powdery matter, which the air brings over in the form of smoke, is not intended to be taken into the lungs, the air should be kept twelve hours at least before it is used, that it may make its deposit.

DIRECTIONS

DIRECTIONS

FOR

PROCURING THE AIRS.

THE directions here given are not intended to comprise all the methods of procuring each air, but merely those which have been found the cheapest and most easily practised. For the history of Factitious Airs, their chemical qualities, and the means of judging of their purity, the reader is referred to the last edition of *Dr. Priestly's Experiments*, in 3 vols. 8vo. to *Lavoisier's Elements of Chemistry*, and for a concise general view of the subject, to *Nicholson's First Principles of Chemistry*.

I. DEPHLOGISTICATED, or OXYGENE AIR. This air is best obtained from manganese, by mere heat. The methods of obtaining it from nitre, from spirit of nitre, or from manganese, by means of vitriolic acid are objectionable, because some acid always accompanies it in these cases, from which the air is difficultly freed, and this apparatus would suffer from corrosion, unless very troublesome means were employed to purify the air before it arrived at the refrigeratory.

Manganese, for this purpose, should be free from calcareous earth and noxious minerals. A very good kind is found near Exeter, which seems to possess these requisites. The presence of calcareous earth may at any time be detected, by pouring diluted nitrous acid upon the powdered manganese; for, if it contain any,
there

there will be a continued effervescence, which otherwise would not take place.

The manganese to be put into the fire-tube or pot, must be reduced to a coarse powder, all the joints must be properly prepared, and every part of the apparatus fixed in its place, as has been directed; the opening for the water-pipe is to be stopped with an iron plug, or with the water-pipe itself, having screwed down the wire so as to admit no water; but some water may be put into the cup by way of precaution, merely to prevent the escape of air, if the conical wire should not be tight. The fire is then to be lighted, and suffered to burn gently until the air begins to come, when it may be gradually augmented until the air ceases to be produced.

Water is not absolutely necessary in this process, for although it seems rather to accelerate the production of the air, it does not augment the quantity produced. It is therefore as well to make use of the iron plug to stop up one end of the fire tube, instead of the end-piece and water-pipe as above directed.

A pound of the hard part of *Exeter* manganese, yields about 1400 cubic inches of air, highly dephlogisticated, and a very small portion of fixed air, will be absorbed by the water in the refrigeratory. The soft or clayey part seems not to yield so much, but what it does yield is equally pure.

Some manganese yields its air at so low a heat, that it is necessary to have every joint tight, and all the apparatus ready before the fire is lighted. If the manganese happen to be wet, it will be a considerable time before any air comes over.

The

The fire-tube of the large furnace holds about 6lb. of manganese, which will yield about five cubic feet of air; those of the small furnace contain nearly 3lb. and yield about two and a half cubic feet of air.

Mendip manganese contains much calcareous earth, and consequently yields fixed air combined with phlogisticated or azotic air, both in the beginning and end of the process. A pound yields only about 500 or 600 cubic inches of impure dephlogisticated air, of which about one third part is absorbed by washing it with lime and water. To ascertain the point at which it begins to yield dephlogisticated air, take out the plug in the conducting pipe, from time to time, and hold a lighted candle near the hole; from the brightness of the flame you will easily discover when the oxygen begins to come and when it ceases, and thus you may be able to keep it separate from other airs.

Objections have been started against the air from manganese, the salubrity of which it is said has not been constituted by experiment, and even if it should be found innocent when taken into the stomach, that as an earthy powder it may have bad effects upon the lungs. To this it is answered, that if the air stand a few hours, it will deposit the merely suspended earth, and what it retains will be in a state of solution in the air, and of too fine a texture to prove hurtful, as soft powders are found not to injure that organ. It is farther answered, that Dr. Beddoes and others have constantly given the air from manganese, without perceiving any bad effects attributable to that cause; and lastly, that no other means of obtaining this air equally unexceptionable, have yet been pointed out. For it seems undeniable, that the fumes of nitrous acid, or of the sulphuric, must prove
much

much more deleterious than the powder of manganese, and they seem almost *inseparable* from the airs obtained from nitrous and vitriolic salts.

II. PHLOGISTICATED, AZOTIC, or NITROGENE AIR. No process for producing this air unmixed with other airs, by means of mere heat, has yet been discovered, but it may be readily enough obtained mixed with fixed air.

Plate 3, fig. 5, represents a chafing-dish, nine inches high and six inches diameter, communicating through the medium of the pipe refrigeratory *n m*, with an hydraulic bellows at *n*. The chafing-dish is to be completely filled, or rather heaped, with the charcoal of some of the softer woods, and in preference to that of the twigs or small branches, previously kindled and made red hot in a common chafing-dish. The trough of the refrigeratory is to be filled with cold water, and the end *n* to be connected with the pipe P of the hydraulic bellows. These must be suffered to rise very slowly, say those of the larger apparatus in five or six minutes. The air which has served to animate the fire, and has there been deprived of its oxygene, will pass through the side pipe of the chafing-dish and the pipe of the refrigeratory into the bellows; and when the operation has been properly performed, it will be found to contain no uncombined oxygene air.

If the use to which this air is to be applied, requires it to be freed from the fixed air it contains, that may easily be effected, by agitating it in the air-holder with a mixture of lime and water, or with a sufficient quantity of pure water.

III. FIXED,

III. FIXED, or CARBONIC ACID AIR. Take as much good chalk as your fire-tube or pot will hold, break it into bits of about a quarter of an inch cube, and soak or boil it in a large quantity of water, to extract any saline matter it may contain. Put it into the fire-tube or pot, and prepare your apparatus, as has been already directed, making use of the close refrigeratory, as represented in *plate 3, fig. 1*; unless, for particular purposes you wish to have your air washed, and do not value the loss of a small quantity; in which case you may make use of the circulating refrigeratory, as has been said before.

When your fire has burnt up, and your fire-tube or pot is become fully red-hot, admit water slowly by the water-pipe, and the fixed air will immediately issue and pass to the bellows.

If you make use of the close refrigeratory, you must renew the cold water in the upper part from time to time, that the air below the diaphragm may be properly cooled, and any steam it brings over with it may be condensed.

Chalk is recommended in preference to marble, as it gives out its air at a lower heat.

The fire-tube of the smaller apparatus, when filled full, which it always should be, as otherwise the steam may pass over without acting upon it, will hold about $1\frac{1}{2}$ lb. of chalk, which will yield about four cubic feet of very strong fixed air, mixed with some inflammable air from the iron tube.

The

The fixed air thus obtained, carries with it some of the chalk in a state of suspension, which it will deposit by standing a few hours in the air-holder, or other convenient vessel.

IV. INFLAMMABLE, or HYDROGENE AIRS.
First, *Zincic Inflammable Air*. The purest, or at least the lightest species of this air is produced from zinc. The metal being broken or granulated, a few pounds of it is to be put into the alembic, and the apparatus being adjusted with the circulating refrigeratory, &c. as before directed, it is to be brought to a strong red heat, and water to be admitted very slowly. It seems impossible to avoid the circumstance of a considerable quantity of steam accompanying the air, which renders it necessary to renew frequently the water in the refrigeratory.

This air carries with it a large quantity of the flowers of zinc in suspension, which it deposits by standing at rest; it probably also contains another quantity in a state of solution, which seems to form a part of its substance, and on which some of its virtues may depend.

If the air is wanted to be still more highly charged with the flowers of zinc, it would be proper to make use of the close refrigeratory.

When the fire-tubes are used in this process, part of the zinc sublimes in a metallic state, and is apt to choak the end pieces; the alembic is therefore recommended in preference, as being free from that inconvenience. Only a small quantity should be put in at a time, as the water could not force its way through any depth of the melted metal.

As

As zinc does not produce very large quantities of inflammable air, and is more expensive than iron, Dr. Beddoes advises to put in only a few ounces of zinc, and to fill up the fire-tube with hammered iron turnings. The air produced in this way will probable carry with it both iron and zinc.

2. *Martial Inflammable Air*, or hydrogen gas from iron, is the next in specific gravity to the inflammable air from zinc, and likewise carries with it some of the metal from which it is formed. It has also more of an hepatic smell than the zinzic air.

To produce it, the fire-tube or pot is to be filled with the turnings or chippings of hammered iron, which may be had from the whitesmiths. Cast iron turnings or borings give much more of the hepatic smell, and also contain more charcoal or carbone. Before the turnings are put into the fire tube or pot, they should be heated red hot in a crucible, and quenched in water, to free them from oil, or other combustibles.

The apparatus is then to be adjusted as in the former cases; and when the fire-tube or pot is red hot, water is to be gradually admitted, which will readily extricate the air.

The fire-tubes of the small apparatus hold about two pounds of hammered iron turnings, which yield a large quantity of air.

When the turnings used for this purpose have not been exhausted, if they are plunged red hot into water, they

they will throw off the scale or calcined iron, and when heated again, will present fresh surfaces to the action of the water.

3. *Heavy Inflammable Air, Carbonated Hydrogene, or Hydro-Carbonate.* Take charcoal made of the twigs of the softer woods, such as willow, poplar, hazle, birch, or sycamore, avoiding such as have resinous or astringent juices. Prepare the charcoal by heating it to full ignition in an open fire, and quenching it in clean water; or by filling a crucible with it, covering it with clean sand, and exposing it to a strong heat in an air furnace; and then suffering it to cool. In either of these cases, it will be found free from any bituminous matter, which might contaminate the air, as generally happens with common charcoal.

The fire-tube or pot is to be heated red hot, and water admitted, as directed in the other cases. It has been observed by Dr. Priestley, and confirmed by my experience, that where much water passes in the form of steam, there is also much fixed air formed; but less, or none, when the water is admitted so sparingly that no steam reaches the refrigeratory; and in the latter case it seemed to me that the air was more potent, that is, it was more subject to cause vertigo, &c.

This air having generally a disagreeable smell, an experiment was made with a view of producing it more free from that quality. Half an ounce of charcoal, finely powdered, was intimately mixed with half a pound of flaked, but caustic lime, quite dry. This mixture was put into the fire-tube, and without the addition of water, produced about a cubic foot of inflammable air, with
much

much less smell than usual, and in the opinion of my operator, not so likely to cause vertigo.

The production of the carbonic inflammable air by the addition of water is very rapid, as even the small fire-tubes will produce a cubic foot in five or six minutes. With the lime the production is slow.

4. *Animal Inflammable Air* is produced by putting any animal substance into the fire-tube or pot, and expelling the air by mere heat; wool, hair, and feathers, produce it in larger quantities than the muscular part of animals. In all cases the air thus obtained is extremely foetid and deleterious, causing vertigo and permanent nausea. It brings over large quantities of volatile alkali, which hurts or destroys the varnish of the apparatus. If it should be thought that it would prove useful in any diseases, it is probable that the air obtained from the charcoal of animal substances may be as salutary, and less nauseous, than that obtained from them in their fresh state. It is therefore proposed to reduce wool, feathers, or hair to charcoal; in a close vessel exposed to a strong heat; to put this charcoal into the fire-tube, and to obtain the air by the addition of water; by which process it is thought it will be obtained more free from the foetor, and from the volatile alkali.

MISCELLANEOUS OBSERVATIONS.

IN every operation in which water is requisite to the production of the airs, the fire-tube should be filled compleatly with the bruised material, otherwise the steam would pass over the substance without acting upon it. This precaution also renders the production of the air more rapid and certain, and at the same time lessens the proportionate produce of inflammable air from the fire-tube, which, especially with a new tube, might otherwise form a considerable part of the whole.

A *Coating* for the inside of the fire-tubes which would prevent the action of the steam, or other substances on the tube, is desirable, but none which completely answers that purpose has hitherto occurred. The best has been the lute of China clay and solution of borax. To apply this, the tube should be made as warm as the hands can bear, and one end being stopped up by the plug, the lute ready mixed up to the consistency of cream, is to be poured into the tube. The other opening is then to be stopped, the tube agitated in all directions for a short time, and the lute, which does not adhere, suddenly poured out; after which, the tube must be rolled upon a table until the heat has evaporated the water of the lute. It is probable that this lute might be improved by an addition of calcined flints ground to fine powder, such as are used in the Staffordshire potteries.

When

When the inflammable air is prepared by means of zinc, the pot should be coated in this manner, to prevent the zinc, or its calx, from adhering to the iron, which it would otherwise do, and be difficultly got off.

Earthen tubes or pots, which would be air-tight, and would stand repeated heating and cooling, would be a valuable acquisition; but considering every circumstance, this seems hardly practicable, as the crucible compositions which are best adapted to bear the heating and cooling, are too porous to contain the airs, and generally too tender to bear the fitting in of the end-pieces.

From some circumstances it appeared probable, that the matter which communicated smell to the inflammable airs, might also be the cause of vertigo, and other disagreeable effects; it was therefore attempted to deprive them of smell. A quart bottle was filled with some very ill-scented hydro-carbonate, and an eight ounce vial, with a mixture of calcined charcoal-dust and water. The mouths of the two were luted together with a strip of bladder, and inverted; the contents of the vial fell down into the bottle, where it was well agitated with the air, the apparatus was then reversed, and the operation repeated more than once. On opening the bottle, it was found that the air had lost its *bad* smell; its odour was not entirely gone, although what it retained was not unpleasant. However I soon found, by merely smelling at the mouth of the bottle, that it had not lost its power of causing vertigo. Conceiving these smells to be caused by sulphur in some of its forms, it was thought that a *metallic calx* might produce the same effects. The powder of calcined manganese was substituted for the charcoal in another experiment, and apparently produ-

ced a still more powerful effect. The process with charcoal was attempted upon a larger quantity of air in the air-holder, but it was found that it required considerable quantities of charcoal-dust and of water, to produce the effect even in an imperfect manner. The experiment, however, seems worthy of repetition, as the smell, with people of delicate nerves, will always be some obstacle to the free use of the airs.

In the mean time, it is recommended to try the following method in the extrication of inflammable air from charcoal and from iron. When you charge the tube, fill it half or three quarters full with clean washed and calcined sand, the kind called *Calais sand* seems the most proper, and upon this put the charcoal or iron to be operated upon, which will thus lie next to the water-pipe. The air produced must pass through the interstices of the red hot sand before it can arrive at the refrigeratory, and it is expected will be considerably changed by thus coming into contact with so much hot surface. The experiment may be varied, by substituting caustic slacked lime,* or clean pounded tobacco pipes, in lieu of the sand.

Whether the Hydro Carbonate thus obtained in a purer or more inflammable state, would have the same virtues as a medicine, must be left to Physicians to determine; I fear it would not, as it would approach near to the nature of the metallic inflammable airs, which are not so powerful.

If the fire-tube is entirely filled with sand, and the vapour of spirits of wine, or of ether, from a small retort,

* When lime is used, the hydrocarbonate will be desulphurated, and considerably altered in its qualities.

are made to pass through it, inflammable airs will be produced of the nature of hydro carbonate, though specifically somewhat different.

REFERENCE to the PLATES.

PLATE I. *Fig. 1*, Elevation of the Large Pneumatic Apparatus, with the Alembic. *Fig. 2*, Bird's Eye View of the Furnace, with its Covers. *Fig. 3*, Section of the Fire-tube and Furnace, according to the first Construction.

PLATE II. *Fig. 1*, Section of the inner and outer Vessels of the Hydraulic Bellows. *Fig. 2*, Section of the outer Vessel of the Circulating Refrigeratory. *Fig. 3*, Section and Plan of the inner Vessel of the Circulating Refrigeratory. *Fig. 4*, Section of the Alembic and Water-pipe. *Fig. 5*, Section of the upper Part of the Water-pipe, and View of the Conical Wire.

PLATE III. *Fig. 1*, Elevation of the Large Pneumatic Apparatus, with the improved Furnace Fire-tube, Close Refrigeratory, and Air-holder. *Fig. 2*, Plan of ditto. *Fig. 3*, Section of the Furnace and Fire-tube. *Fig. 4*, Section of the Small Furnace, with Sand Bath, Retort, and Chimney adapted for Distilling. *Fig. 5*, Section of the Pipe Refrigeratory.

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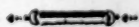
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ADDENDA.

THE following letters (except that from Mr. Field) immediately respect the subject of the pamphlet, and I make no apology for adding them here. Mr. Field's is of great importance; and with the facts I have published in my translation of Mr. Gimbernat's Essay on the Femoral Hernia, seems to go near to demonstrate the superior safety of inoculating with diluted matter. Dr. Jenner's opinion of the nature of tubercles I know to have been formed without the knowledge of a similar opinion on carcinoma. It will infallibly give rise to new researches, and if confirmed, may lead to an effectual method of cure. — I am this moment informed that Dr. Girtanner, of Goettingen, has succeeded in the cure of some cases of consumption, by giving one part of carbonic acid air in conjunction with three of atmospheric. He employs a mouth-piece with double valves; such as Mr. W. Yonge projected at the commencement of this practice, and such as Mr. Watt has carried to great perfection: Dr. Lawrence, physician, at Swafham, Norfolk, informs me that he has succeeded in some of those cases where he has used factitious airs. I hope to obtain an account of his experience for a fourth part of these Considerations.

T. B.



Kingscote-House, Feb. 9.

DEAR SIR,

Your proof-sheet has just reached me. I observe an error, *infested* for *infested* (8th line from the bottom, page 178.)

Q

My

My hasty letter of the 29th Jan. would have been more explicit had the idea of hydatids being the cause of tubercles in the lungs been elucidated by a comparison with insect-irritation among vegetables. Here we see a variety of excrescences evidently of insect origin. It is clearly demonstrated in the oak-apple and the gall-nut ; but in nothing more beautifully or familiarly than in the mossy excrescence that springs from the wild-rose or the sweet-brier. Your's, &c. E. JENNER.

To Dr. Beddoes.

P. S. If from further investigation it should appear that my opinion of the first existence of tuberculous consumption be just, your mode of treating the disease, especially in its early stages, may prove highly important ; as the factitious airs you introduce into the lungs will probably be deleterious to the hydatid, before it is defended from injury by too thick an incrustation. With this view, I long ago directed patients to inhale the vapours of tar, made warm, and diluted with oil of turpentine ; and, I think, with manifest advantage. As a demonstration that turpentine is destructive to hydatids, I have a curious fact to make public. There is only room now just to say, that a young man who had hydatids in his kidneys was presently cured by the use of oil of turpentine. It was principally sent into the system through the skin.



DEAR SIR,

Conceiving that the following facts have a strong tendency to support your hypothesis relative to the origin of sea-scurvy, I beg leave to lay them before you.

A very

A very respectable family in this neighbourhood, consisting of an elderly lady and her three daughters, quitted a town residence a few years since and retired into the country. At this time they enjoyed very good health. Not long after they occupied their new habitation an unpleasant change began to appear in the constitution of the eldest of the young ladies, and soon after in the youngest. It first shewed itself in an aversion to exercise and a loss of their accustomed spirits and vivacity. This was followed by the appearance of broad livid spots on the skin, resembling *ecchymoses*, which were surrounded by clusters of small pustules that itched intollerably. Frequent hæmorrhages also took place from the nose and gums ; and one of the ladies, the second sister, (on whose skin no livid spots or pustules had ever appeared) was twice affected with hæmorrhages from the stomach, so profuse that they had nearly proved fatal to her. In no one of the family were the symptoms so violent, the hæmorrhage from the stomach excepted, as in the eldest. She gradually sunk under their pressure, and died. For some months previous to this event, her countenance assumed a bloated appearance, her legs became œdematous, and an ulcer appeared on one of the ancles. Her mental faculties were much weakened, and during the last fortnight of her existence, she lay in a state of perfect insensibility ; for the most part comatose.

It was impossible to perceive these symptoms without being struck with their similitude to those of scurvy, but the probable exciting cause did not occur to me until I perused your publication on the subject,

Q 2

when

when it immediately suggested itself that the family were affected with the symptoms above related from breathing air far beneath the purity of that of the common atmosphere. The chimney of the room where they commonly lived was ill constructed and without a free ventilation. I scarcely ever entered the apartment without being sensibly affected with the peculiarity of the smell.—It was not merely that of a smoaky room but seemed to partake also of the smell occasioned by pouring water on hot coals. The grate made use of was a common Bath stove, in which there was pretty constantly a fire made of pit-coal both in summer and winter.

I remain, Your's, &c. E. JENNER.

To Dr. Beddoes.

Worcester, Feb. 8th, 1796.

DEAR SIR,

Having lent your account of the good effects of diluting variolous matter, for the purpose of inoculation, to my friend, Mr. Field, of Evesham; he returned it to me, with the following letter; which he has allowed me to communicate to you for publication, and which, I am well persuaded, you will think contains information of sufficient consequence to interest practitioners and the community.

I am, &c. W. SANDFORD.

To Dr. Beddoes.

Evesham, Jan. 9th, 1796.

DEAR SIR,

I am much obliged for the perusal of the pamphlet herewith returned.

How

How very frequently do we observe things offered to the public, as new discoveries, which others have long been acquainted with. The first person shall be long in the practice of the improvement, without esteeming it of consequence enough to publish; whilst the person who makes a similar discovery, unconscious of its being known before, presents it to practitioners as new and important.

For upwards of twenty years I have been in the practice of inoculating with variolous matter very much diluted, even beyond what Dr. Beddoes or his correspondents make mention of, and with a success that has often surprized me. The number of patients inoculated by myself and pupils must exceed TWO THOUSAND, without the loss of more than ONE; and I believe I may say with scarce a sinister accident. — Instead of taking a goose-quill *full* of matter at a time, which is frequently done I believe, I have not, I am confident, expended more than a drop or two, for the last twenty years. If I have thirty or forty persons to inoculate at the same time, I only moisten the point of a lancet with the matter, and let it dry on. I always prefer the thin pellucid matter, which is to be obtained in the early stages of the disorder, before maturation and perhaps a day or two after the eruption (if from inoculated patients), to that which is more concocted and purulent, because I find it more infectious and because it dissolves better, and mixes more intimately with any aqueous menstruum. I cannot ascertain precisely the degree of dilution in any instance, but I presume it must in some have been in the proportion of 100 p. to 1.

I remember having some talk with my brother at Worcester on that subject a good while ago, when I proposed

proposed mixing a single drop of variolous pus with an ounce of warm water ; whether he has considered it or adopted the practice I know not ; for myself I can only say I am not an experimental man, but I doubt not from what I have observed, that matter so diluted would give the disease to as great or greater certainty than thick matter ; and I have every reason to believe, in a milder degree ; for where I have one patient complaining of too large a burden, I have fifty who are not satisfied with their number of pustules : and I have had many who have passed through the disease without being able to discover any eruption, which I should always think fortunate, if my patients or their friends would be of the same opinion,

Though the matter I inoculate with is so much diluted, I use the smallest quantity possible, and scarcely ever draw blood, yet I do not fail to infect once in many hundred times, and am therefore persuaded, that the *absorption* of thin diluted matter is more certain, than *of that* which is thick ; and the puncture I make under the cuticle being so slight as not to produce inflammation or digestion, the matter cannot be thrown off before absorption takes place.

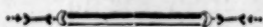
The following circumstance that once occurred to me seems to prove the thin variolous matter to be more infectious than may be generally imagined. Having sent almost all my lancets to London to be ground, and being disappointed in my expectation of receiving them back so soon as I expected, from use or accident the few lancets in my possession were

at

at that time unfit for bleeding, except one that had been kept with variolous matter on it for the purpose of inoculation. This lancet I was at last reduced to the necessity of bringing into use for bleeding; previous to which I washed and cleaned it so assiduously, that a lancet just ground could not possibly have appeared more clear and beautiful in its polish. Yet the next person I bled with it called a few days after complaining of a sore arm, when it was evident to me, from the appearance of the orifice, and pain in the axilla, that I had inoculated him by bleeding: and a short time rendered it certain, by the appearance of the small pox, which he had, in a very favorable manner.

I remain, &c. B. FIELD.

To Mr. SANDFORD.



While the preceding pages were printing, I heard of the death of a lady, to whose carcinomatous breast carb. acid air had been previously applied. I was told that the breast had healed with prodigious rapidity; and mindful of the propriety of publishing cases where injury has occurred from factitious airs, I wrote to the surgeon who had attended. There seems no connection between the effect of the air and the patient's death: Nor did Dr. Ewart's patient suffer from the healing of her breast. Yet, when an old ulcer is healing apace, would it not be prudent to open an issue?

Newcastle, Feb. 2, 1796.

SIR,

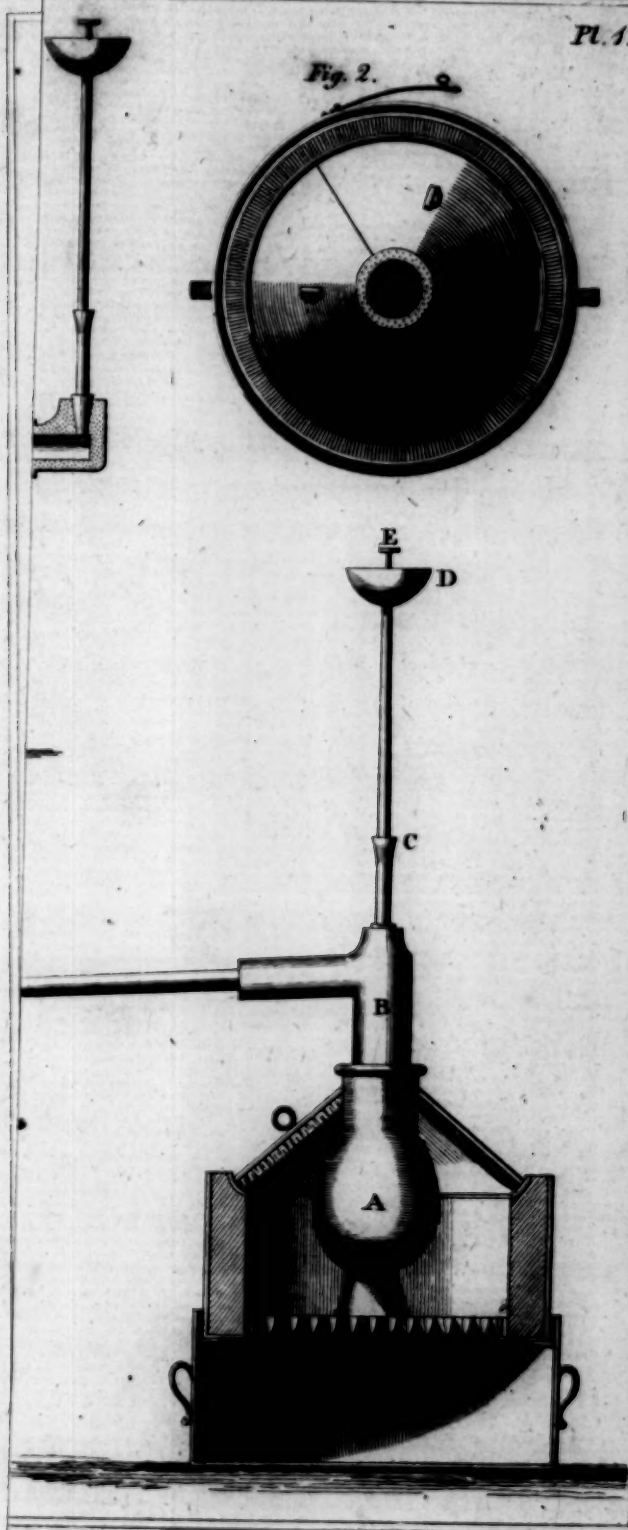
As I only attended Mrs. R—— W——— occasionally, I cannot give you the particulars of her case
so

so exactly as I could wish. In regard to the effects of the carbonic-acid gas, it appeared to me to relieve the pain. There never was much discharge from the wound; before the application of the gas, it was covered with a brown scab, which came away, and the wound healed. There was a great number of small tubercles all over the breast, and the lymphatic glands in the arm-pit were enlarged; these were *very much reduced* in size, and the pain lessened. As these were caused by the absorption of the matter, I attributed their amendment to the matter being rendered more mild from the application of the gas; an effect I have seen more than twenty years ago from the same application. I cannot attribute her death to the healing of the wound, as the other breast became diseased afterwards, and the discharge from the former was always very trifling. The liver in Mrs. W———'s case, was evidently diseased from the beginning of her complaints, and before there was any appearance of cancer in her breast; and, in my opinion, she was more relieved from small doses of calomel, and steel, than any other medicines. I always thought her taking oxygene was prejudicial. Before she died there appeared a tumour upon the liver, which increased to a large size; but as I had no opportunity of examining the body after death, cannot say any thing more. I have long been of opinion, that all *truly cancerous* complaints are preceded by some of the liver; but to explain my ideas on this subject, would lead me beyond the bounds of a letter.

I am, with much respect, Your's, &c. J. BENT.
To DR. BEDDOES.

F I N I S.

Fig. 2.



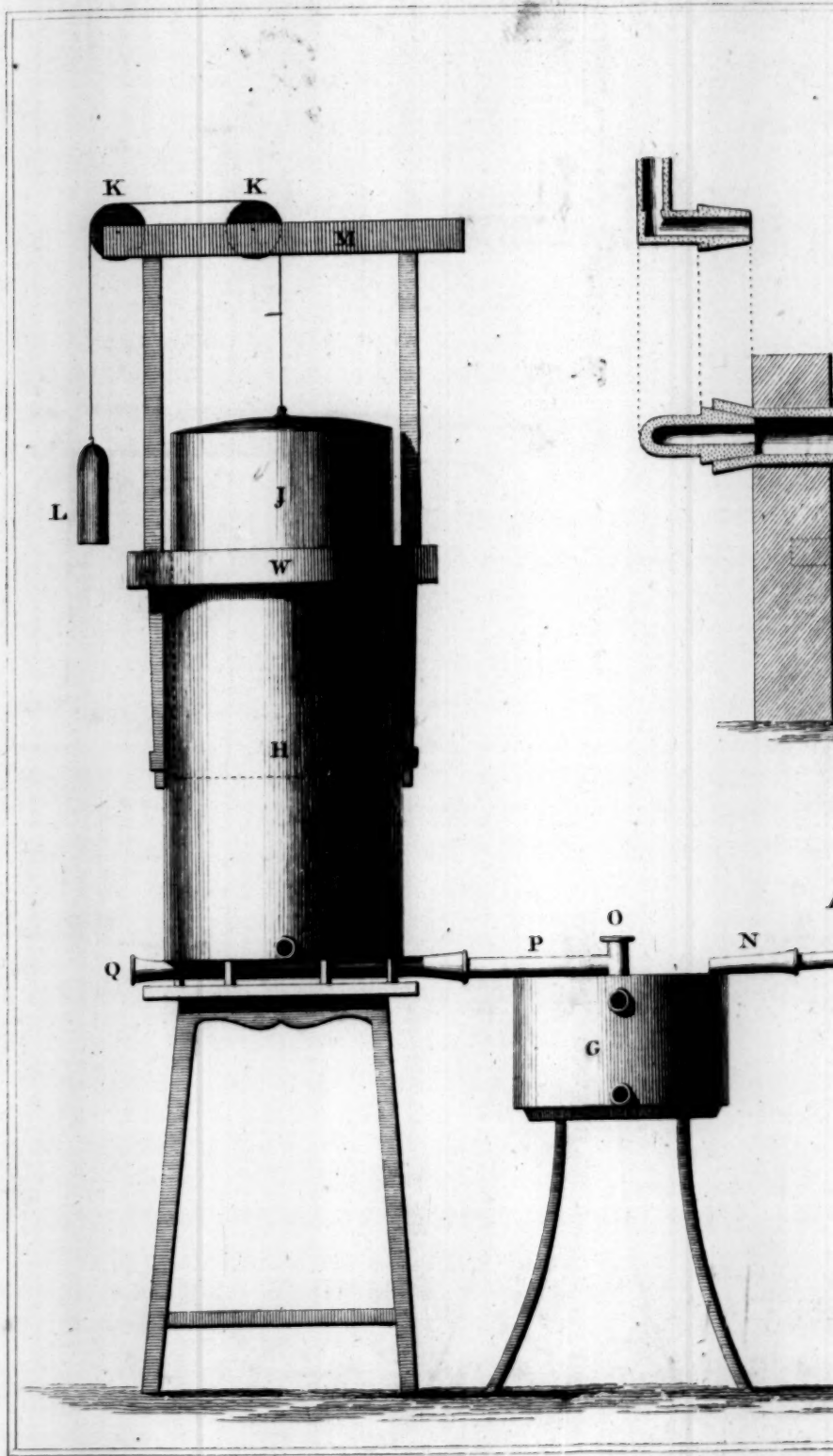


Fig. 2.

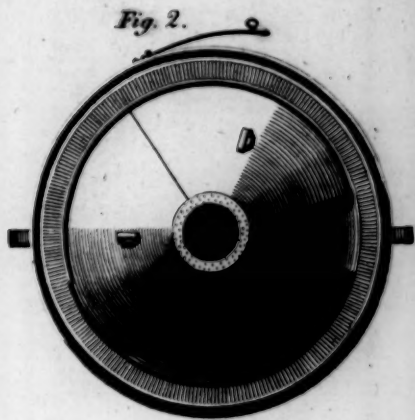


Fig. 3.

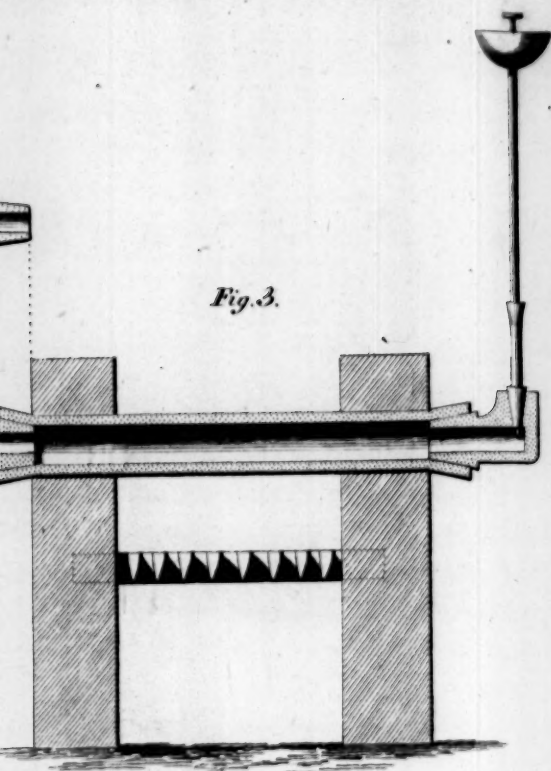
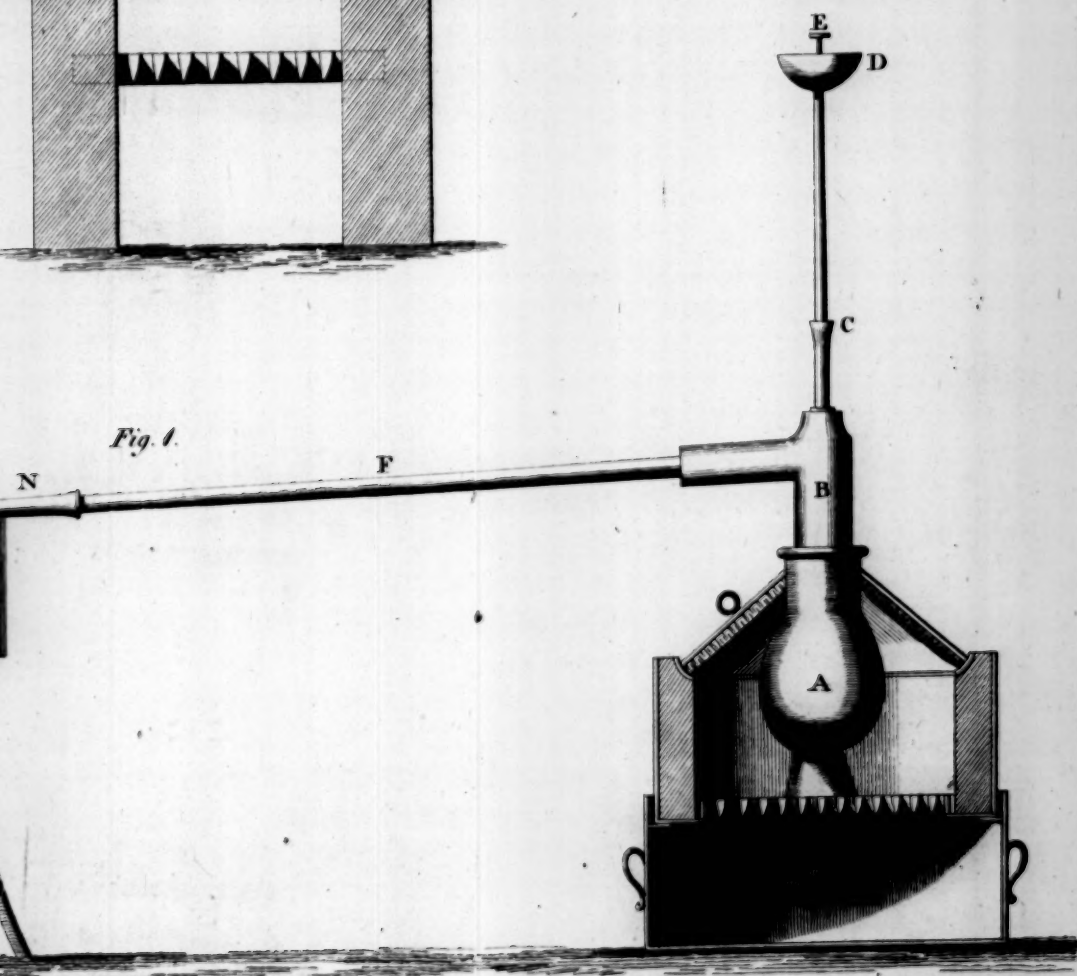


Fig. 1.



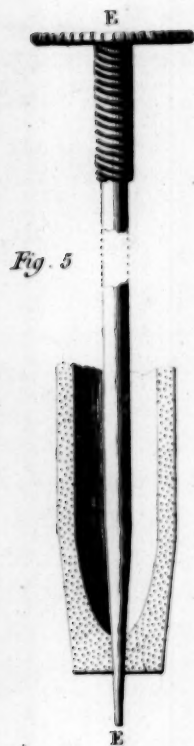


Fig. 5

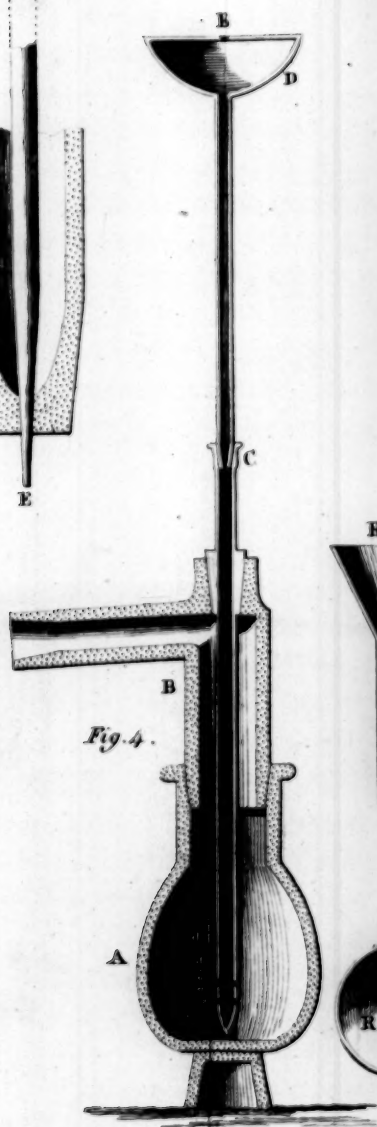


Fig. 4.



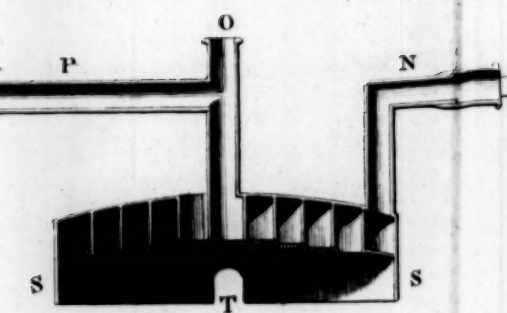


Fig. 3.

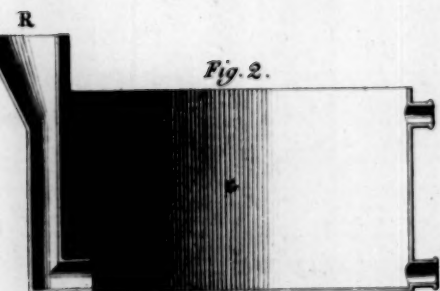
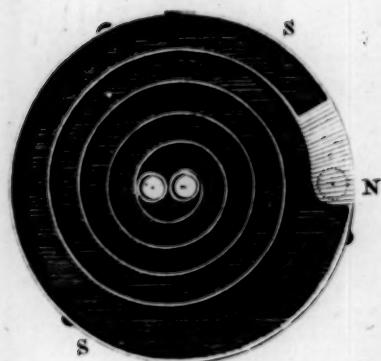


Fig. 2.

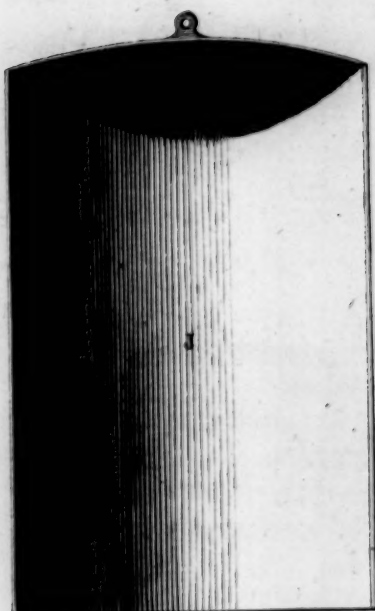
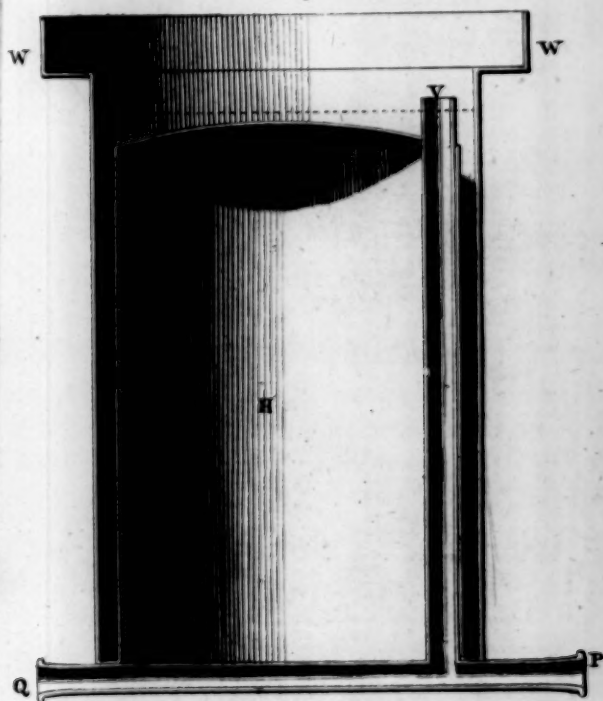


Fig. 1.



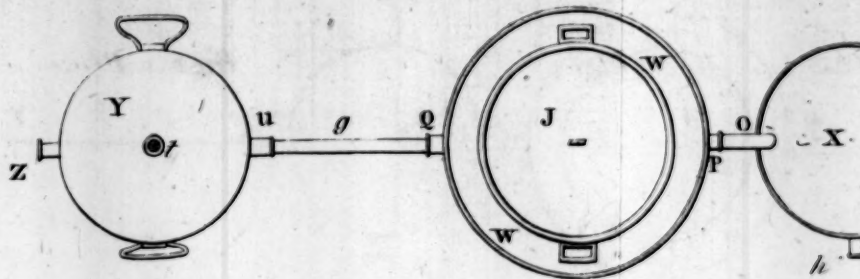


Fig. 4.

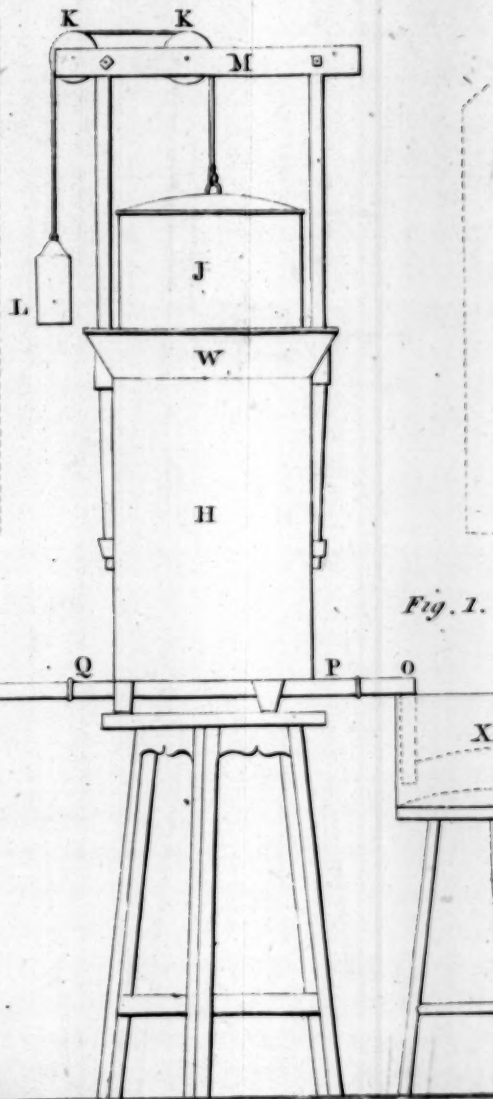
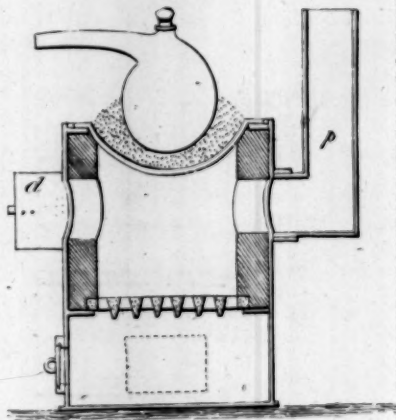
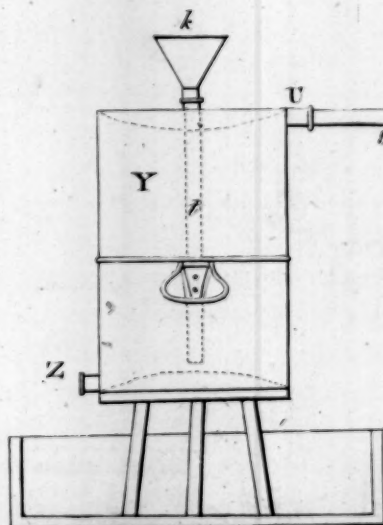


Fig. 1.



Scale of

Fig. 2. Plan

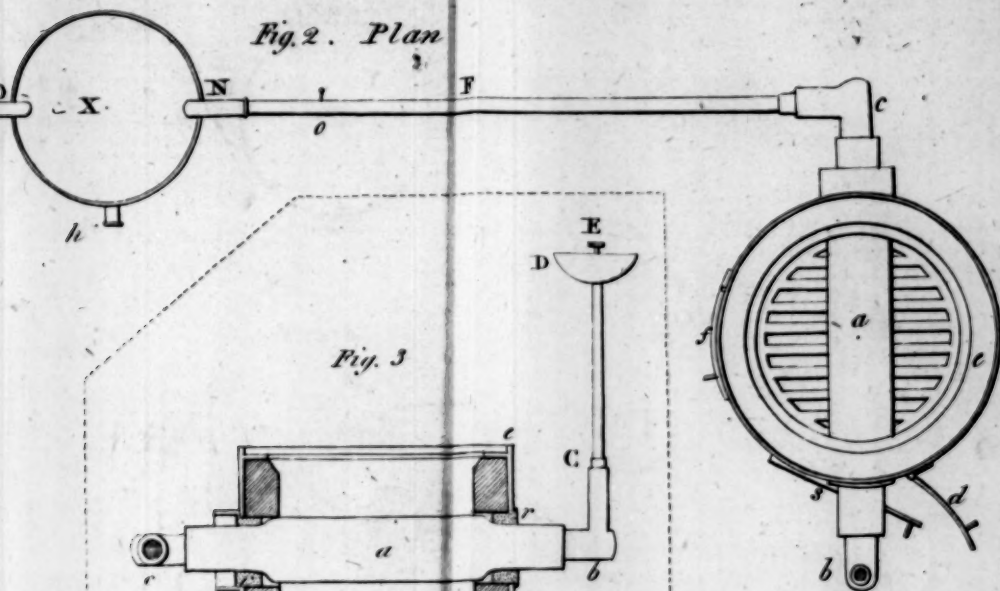


Fig. 3

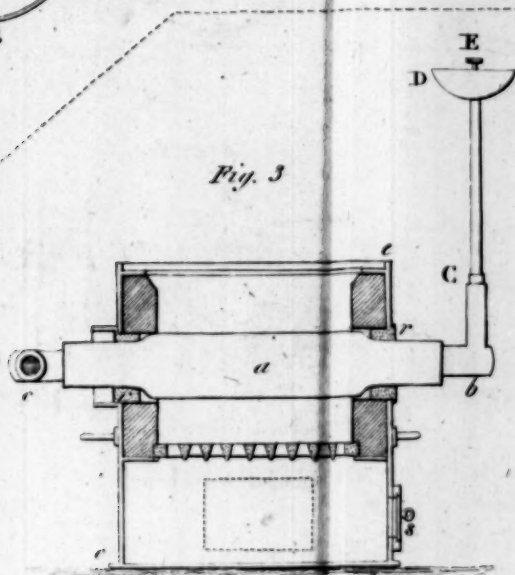


Fig. 1.

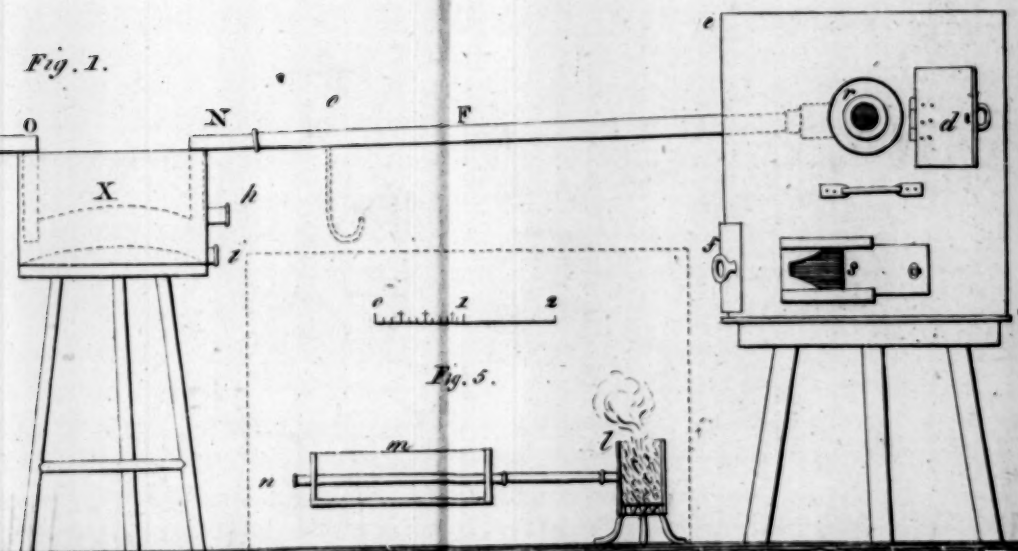
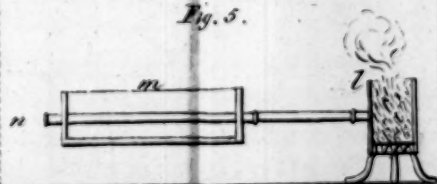


Fig. 5.



3 Feet for Fig. 1. 2. 3. 4.

Plate IV.

Fig. 1.

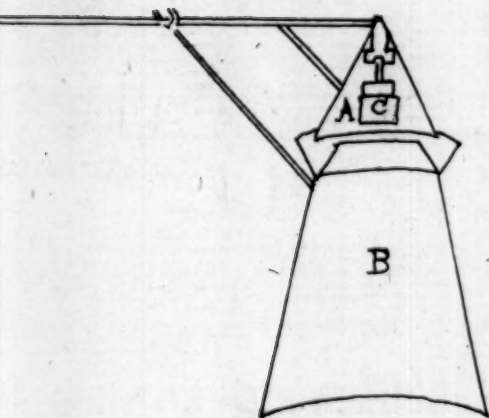


Fig. 2.

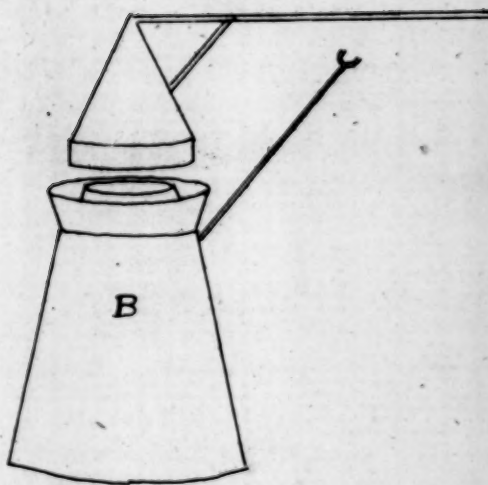


Fig. 3.

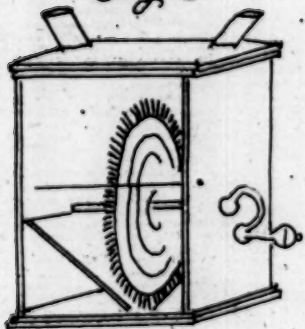


Fig. 4.

